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ABSTRACT

The objectives of this study were to modify the Test of Science Processes (Tannenbaum, 1968) for use by intermediate level students, and to adapt this test for use through the medium of television. The resultant instrument, the Television Test of Science Processes, was developed and tested for content validity, appropriate readability, internal reliability, criterion related validity through correlation with similar instruments, and norming. Extensive appendices illustrating draft instruments, statistical results, and evaluation materials are provided. (MH)

SCIENCE FOR THE SEVENTIES

The Television Test of Science Processes

by David R. Torrence

The Pennsylvania Department of Education

The Pennsylvania State University

The Graduate School

Division of Academic Curriculum and Instruction

The Television Test of Science Processes

A Thesis in

Academic Curriculum and Instruction

by

David R. Torrence

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Education

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teachers and administrators throughout the Commonwealth of Pennsylvania have helped to bring this project to fruition.

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CHAPTER I

INTRODUCTION

Background

During the past several years, scientists and science educators have expressed a need to emphasize the processes of science as unique and coequal with the product or content of science. As a result, many science curricula have incorporated science processes as a teaching priority.

In 1968, the Pennsylvania Department of Education (PDE) embarked on a statewide thrust to assist elementary teachers in a transition into some of the newer methods of teaching science. This effort was called Science for the Seventies (PDE, 1971). In 1972, The Pennsylvania State University and PDE devised a system for using instructional television as a major resource in the dissemination and implementation of Science for the Seventies (SFTS) for elementary school classrooms throughout Pennsylvania. (Shrigley, Alfke, Szabo, and Welliver, 1975)

It encompasses a teacher's guide which deals with the pedagogy of contemporary elementary science education, a growing set of primary and intermediate grade science lessons, ten fifteen-minute televised programs for use with primary grade students, ten twenty-minute televised programs for use with intermediate level students, five in-service televised programs to help teachers use SFTS-ITV Handbook for Teachers which provides an orientation and instructions in the use of the resource (PDE, 1975). The function of SFTS in the science curriculum is summarized as having the following role:

> SFTS, including both the TV components and the printed materials, is not a K-6 science curriculum; rather, it is a resource for teachers. The philosophy of SFTS is compatible with such inquiry programs as SCIS, ESS, and S-APA. Therefore, SFTS could serve as either a bridge or a supplement to any of the three programs mentioned.
>
> Secondly, SFTS could be the model around which a school district could build, over the years, a K-6 inquiry-type science curriculum. This would mean adding many lesson components to the 25 published by PDE.
>
> Thirdly, SFTS could be the inquiry component to a conceptually oriented science curriculum. Teachers could pick and choose those lessons that reinforce an already established curriculum.
>
> Fourthly, the SFTS tapes and the accompanying lessons, plus SFTS lessons published but not placed on tape, comprise enough materials to provide a four-month springboard to science for new primary grade teachers in a school district. Or a school district having no ongoing science curriculum might introduce all of its primary teachers (and perhaps intermediate teachers) and pupils to investigate science teaching through the four-month SFTS resource. (Shrigley, et al., 1975, p. 501)

One of the stated objectives of this statewide ITV resource emphasizes science processes:

> Following the broadcasting of SFTS oriented televised lessons, children in participating classrooms will exhibit a measurably significant increase in their facility in the use of science processes. (SFTS Phase I Project Report, 1974, p. 21)

Relative to the above terminal performance objective, a tentative projected performance measure was drafted:

> A televised test will reveal increased student competency in the use of science processes and attainment of aims and objectives of SFTS. (SFTS Phase I Project Report, 1974, p. 24)

Several tests have been developed to assess the acquisition of those skills and abilities collectively described as science process. Some of the tests are the S-APA (Science -- A Process Approach), Science Process Instrument (SPI), American Association for the Advancement of Science, 1970; the Processes of Science Test, Biological Science Curriculum Study, 1962; The Science Process Test (TSPT), Ludeman, 1974; the Science Observation and Comparison Test (SOCT), Hungerford and Miles, 1969; the Science Test for Evaluation of Process Skills (STEPS), Morgan, 1971; the Test of Science Processes (TSP), Tannenbaum, 1968; and the science test of the Comprehensive Tests of Basic Skills (CTBS), McGraw-Hill, 1973.

Once the decision to use a test of science processes to gather data about intermediate grade school children in Pennsylvania was made by members of the Science for the Seventies Committee, several tests were investigated for possible use. No test reviewed possessed the combined requirements of being valid for use by intermediate level students and for use via the television medium. However, the available tests purporting to measure science processes, the Test of Science Processes (Tannenbaum, 1968) was judged to be adaptable for intermediate grade use because it was an instrument at least possessing content validity. (See Appendix A for letter of release.) Also the processes categorized as subtests by the author encompassed most of the processes listed by science educators. Most applicable to the SFTS objectives was its visual presentation mode which had implication for the television format. A television format has the advantage of providing repetition, clarification, and motion cues to the questioning procedure. There were two reasons why the Test of Science Processes in its original form was not appropriate for use as the assessment instrument for the SFTS: (1) the test was designed for junior high school level, and (2) it was designed for 2x2 35mm slide presentation.

Statement of the Problem

Because television is a major component of the SFTS resource, it was logical for a test to be produced in the same medium. A television test would compliment the total SFTS television package, would provide a free testing resource to teachers and administrators, and would provide uniformity in test administration. Television provides the least expensive delivery system for the presentation of the visuals required in the testing situation.

There are two aspects to the problem investigated in this study. First, could the Test of Science Processes be modified for use by intermediate level students; and second, could the TSP be adapted for use through the medium of television? The adaptation of an existing instrument involved a replication of the steps used to create the initial instrument as well as the addition of several new steps unique to the production of the second instrument. These steps were to derive content validity, to produce the print and non-print components, to establish the reliability through item analysis, to empirically validate and to establish norms.

Assumptions

Certain assumptions must be stated in order to justify the modifications and adaptation of the Test of Science Processes. Selection of item content as content valid process questions rests on the assumption that the TSP is a reasonably reliable and valid instrument for assessing achievement in the use of science processes for students in grades seven, eight and nine.

Validation of the modified instrument, the Television Test of Science Processes (TTSP), requires correlation with other instruments purported to measure science processes. The tests used for this study were The Science Process Test (Ludeman, 1974) and the Comprehensive Tests of Basic Skills, Test 9 (McGraw-Hill, 1973). A statement of concurrent validity is built on the assumption that The Science Process Test is a reasonably reliable and valid instrument which assesses students' ability to use the integrated processes of interpreting data, controlling variables, formulating hypotheses and defining operationally as defined by S-APA. A third assumption is that the science test of the Comprehensive Tests of Basic Skills is a reliable and valid instrument which assesses student's ability to investigate problems in science and, to a lesser degree, to recall scientific facts or concepts.

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evision Test of Science Processes (TTSP), relative to the the Seventies ITV resource, has several potential 1) provide pretest entry data in an empirical study to effectiveness of SFTS exposure, (2) survey general student rformance on science processes on a statewide scale, and additional evaluative instrument to assess mastery of esses.

re general sense, production and validation of the TTSP seful addition to the small number of tests of science ailable to educators. The instrument is unique in its dality. It should be a valuable resource for elementary hers and administrators, researchers in elementary science nstructional developers working with television projects y science, and should provide a valuable source of data ng research in elementary science, process testing, and esting.

f Terms

ds -- Electronic Data Processing cards, commonly called

ic Density -- a method of generating a readability measure use of a computer program that synthesizes phrase and istruction.

-- the skill and competency required for systematic investigation.

<u>Product</u> -- the content or body of cognitive knowledge of a discipline.

<u>Multiplexer system</u> -- the hardware used to enable a television camera to receive images from several projection sources.

<u>Cross-channel redundancy</u> -- the presentation of identical information through the auditory and visual channels.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

This review of literature surveys those topics deemed most relevant to the central elements of the project. No attempt was made to review the literature relative to aspects of the methodology of test construction. Tannenbaum's format for test development is the "blueprint" or two dimensional matrix suggested by Travers (1950). This aspect of the project is replicative in nature.

The present review is subdivided into five sections: the value of teaching science processes, defining science processes, tests of science processes, the Test of Science Processes, and television testing. The first area of review explores the pedagogy relevant to science processes. If the process is to be tested, a case must be built supportive of the process as a variable worthy of assessment. The value of the testing instrument rests wholly on its ability to contribute to the needs of relevant educational problems. Ennis (1963) suggests that process abilities require new approaches to testing.

A second area of review deals with the meaning of science processes. In order to test these processes, there must be general agreement as to what constitutes these processes in total or in discrete components. Certainly, content validity can be acceptable to the academic community only to the extent that there is agreement on what constitutes science processes.

A third area is a review of tests of science processes. The project grew from a need for an intermediate level science process test. A review of the existing instruments found no test instrument especially suited to the needs of SFTS.

A fourth area is a review of the Test of Science Processes (TSP). Whereas this instrument is central to the TTSP in both theory and practice, an in-depth understanding of the rationale and methodology of the TSP contributes to the data base underlying the entire project.

The fifth area of review is television testing. A survey of television testing to date provides valuable input for presenting a testing situation via television.

The Value of Teaching Science Process

In recent years, science process as a discrete entity or as a collection of unique and identifiable variables has become a subject of much educational interest. Some scientists and educators have used such terms as problem solving, discovery learning, or inquiry to characterize the science processes (NSEE, 1960; Kessen, 1964; Blackwood, 1964). Regardless of the terminology used, an attempt to differentiate the two kinds of learning has been made; that of "product" and "process." The distinction between the product and the process of a discipline is stated as:

> The traditional aim of instruction has been knowledge. Psychological research into learning, however, has found the need to consciously develop a system in the learner whereby he can learn. This 'process' of learning, the skills and attitudes of

> learning, has come to the forefront in modern educational research as a goal equally as important as the attainment of the desired knowledge -- the 'product'. (Torrence, 1969, p. 12)

It is generally agreed that the introduction of science process into the modern science curriculum is an innovation which has occurred recently. Contrary to this belief, however, is an assertion made by Harvey (1902) which expressed the belief that the procedure of investigation was the most significant contribution to education made by science and that these procedures had additional value in being able to be applied to other areas of human activity.

Raskin (1956) and Rutherford (1964) have emphasized the understanding of the nature of science by stating that critical thinking, problem solving, discovery, inquiry, and other science processes should be foremost in the teaching of science. Gruber (1962) states that educators should allow the student to experience the science processes in order to learn how science knowledge is obtained. In Gruber's view, instruction in the accumulation of facts would limit intellectual development and impair a student's ability to solve problems.

Evans (1953) advocated the teaching of science process as it is related to science technique and knowledge. Separation of knowledge and process would not only dilute the functional value of scientific knowledge already established, but would inhibit the dissemination of the science processes. Blackwood (1959) believed that students skilled in the processes of science could become more scientific in problem solving.

Nelson (1959) addresses the question of what science educators believe to be the primary objectives in the science curriculum:

> The objectives of science teaching should logically eminate from our operational definition of science. If science means primarily organized knowledge, then the learning of facts, concepts, and principles would be the major activity with which science teachers and students ought to be concerned. If science involves the acquisition of intellectual abilities and skills, then teaching and learning situations conducive to the attainment of such abilities and skills ought to constitute a major aspect of science teaching. (Nelson, p. 20)

It can be argued that if emphasis is placed on the how and why in an atmosphere of inquiry and investigation, the students will then be encouraged to develop resourcefulness in the solution of new problems confronting them outside the classroom.

Piaget has had a substantial impact on educators. Following are some of Piaget's comments in respect to the aims of education and the importance of teaching "process":

> The goal in education is not to increase the amount of knowledge, but to create the possibilities for a child to invent and discover. ...the principal goal of education is to create men who are capable of doing new things, not simply repeating what other generations have done -- men who are creators, inventors, and discoverers. ...we need pupils who are active, who learn early to find out by themselves, partly by their own spontaneous activity and partly through materials we set up for them; who learn early what is verifiable and what is simply the first idea to come to them. (Duckworth, 1964, pp. 174-175)

Tyler (1962) advocates the importance of the mastery and use of the science processes as tools which the individual uses throughout his lifetime in order to "make sense" out of the universe:

> If students are to understand science and contribute to its intellectual development, they need to understand it as a process of continuing inquiry and reconstruction of knowledge. ...a science course becomes an introduction in 'learning how to learn' science, an effort to start the student on a lifelong endeavor to make sense out of his experience with the material world, and the observations made of natural phenomena, as well as environment. (Tyler, 1962, p. 24)

Bruner (1961) also advocates the importance of teaching science process, but questions what should be taught in order to gain the best effects:

> It is my hunch that it is only through the exercise of problem solving and the effort of discovery that one learns the heuristics of discovery, and the more one has practice, the more one is likely to generalize what one has learned into a style of problem solving or inquiry that serves for any kind of task one may encounter -- or almost any kind of task. ...what is unclear is what kinds of training and teaching produce the best effects. (Bruner, 1961, p. 31)

Bruner feels that learning specific skills of science process is not enough. There are certain attitudes which one must possess in order to gain use of the science processes for application to other problems that may be encountered:

> ...an understanding of the formal aspects of inquiry is not sufficient. There appears to be, rather, a series of activities, some directly related to a particular subject and some of them fairly generalized, that go with inquiry and research. These have to do with the process of trying to find out something. (<u>Ibid</u>. p. 31)

There is general agreement that an emphasis on process should be implemented in modern curricula. This emphasis is expressed by new curricular programs both in science and also in social studies. While educators and learning theorists are in agreement on the benefit of including process in the curriculum either as coequal with content or to the exclusion of content at the elementary level, there appears to be basic differences in their perception of the term "process."

Defining Science Process

Many individuals have attempted to define science processes. As early as 1892, Jevons (1892) stated:

> In every act of inference or scientific method we are engaged about a certain identity, sameness, similarity, likeness, resemblance, analogy, equivalence or equality apparent between two objects. (p. 1)

Jevons characterized science processes as identity and difference, inference, inductive and deductive reasoning, measurement, observation, experimentation, hypothesis, prediction, and classification.

Gagne (1968) defined science process as a highly complex set of intellectual activities which are analyzable into simpler activities and which then may be learned. Processes are forms of information processing; activities which are carried out in a quest for scientific knowledge. Gagne believes that in order to attain the capability of enquiry, an individual needs to learn how to observe, how to figure, how to measure, how to orient things in space, how to describe, how to classify objects and events, how to infer, and how to make conceptual models. If these skills are mastered, the individual will use them all his life.

Curtis (1966) described science processes as tools which enable man's abilities of observation, reasoning and communication to be used. He emphasized the applicability of these processes to other areas of endeavor. Atkin (1968) believed process to be the same as problem solving, scientific method, and inquiry. Conant (1953) defined the processes of science as activities, skills and tools of research which an individual may use in his investigations.

The American Association for the Advancement of Science (AAAS) (1964) listed eight skills and abilities as constituting the science processes: (1) recognizing and using time/space relationships, (2) recognizing and using number and number relationships, (3) observing, (4) classifying, (5) measuring, (6) communicating, (7) inferring, and (8) predicting. Shamos (1966) characterized science processes as including: (1) observation, (2) classification, (3) measurement, (4) description, (5) comparison, (6) discrimination, (7) experimentation, (8) evaluation, (9) interpretation, and (10) prediction.

Keeslar (1945) compiled a list of ten major elements of the "scientific method" from lists submitted by twenty-two scientists at the University of Michigan. The elements were: (1) sensing a problem, (2) defining a problem, (3) determining the facts and clues bearing upon the problem, (4) making tentative hypotheses, (5) selecting the most likely hypothesis, (6) planning an experiment to test the hypothesis, (7) testing the hypothesis, (8) replicating the experiment for verification, (9) making a conclusion, and (10) making inferences based on conclusion.

Hogan (1969) defines processes of science as "those skills and competencies necessary for deliberate and systematic scientific inquiry (Hogan, 1969, p. 6)." McLeod, Berkheimer, Fyffe, and Robinson (1975) say that:

> ...an ability to use the processes requires one to assimilate information, process that information, and make an intellectual step beyond the information given. (McLeod, et al., 1975, p. 416)

William Kessen (1964) lists the processes of scientific enquiry as: (1) stating the problem, (2) observing, (3) comparing, (4) classifying, (5) measuring, (6) experimenting, (7) hypothesizing, (8) evaluating, and (9) drawing conclusions. He believes that in order to attain the capability of enquiry, an individual needs to learn how to observe, how to figure, how to measure, how to orient things in space, how to describe, how to classify objects and events, how to infer, and how to make conceptual models. If these skills are mastered, the individual will use them all his life.

The questions of the TSP reflect the processes enumerated by Tannenbaum in his "blueprint." They are essentially parallel to those of the AAAS and are: (1) observing, (2) comparing, (3) classifying, (4) quantifying, (5) measuring, (6) experimenting, (7) inferring, and (8) predicting.

While there is much emphasis on the need to provide learning experiences in the use of science processes, it can be inferred from the review of the literature that there seems to be little agreement on which skills and abilities comprise science process. A multiplicity of definitions for process are in use. Table 1 summarizes the skills and abilities or processes described or enumerated by educators or curricula which form the basis of their respective definitions. While several of the processes are not mutually exclusive, they have been listed as somewhat unique within the description of its author.

This imprecision of definition creates a question as to which skills and abilities constitute science process; are these skills and abilities unique in an empirical sense; and, what performance should be assessed in a science process test.

Tests of Science Processes

Although there are several packaged science programs and texts emphasizing the acquisition of science process skills such as Science -- A Process Approach (AAAS, 1967), Science Curriculum Improvement Study (SCIS, 1970), the Elementary Science Study (Duckworth, 1964), and the Conceptually Oriented Program in Elementary Science (COPES, 1966) among the more notable, few tests of science process have been developed. The existing tests of science processes and a brief description of each are reviewed.

The Science Process Inventory (SPI) by Welsh and Pella (1967) is designed to inventory the knowledge of the processes of science

TABLE 1

PROCESSES APPLICABLE TO SELECTED EDUCATORS, EDUCATIONAL PSYCHOLOGISTS, AND SCIENCE CURRICULA

Processes	Tannenbaum	AAAS	Shamos (COPES)	Jevons	Gagne	Curtis	Atkin	Conant	SCIS	ESS	Kessen	Keeslar
observing	X	X	X	X	X	X			X		X	
comparing	X		X						X		X	
classifying	X	X	X	X	X				X		X	
quantifying	X				X							
measuring	X	X	X	X					X		X	
experimenting	X		X	X							X	X
inferring	X	X		X	X							X
predicting	X	X	X	X					X			
communicating		X				X						
recognizing and using time space relationships	X											
interpreting		X						X				
evaluating		X									X	X
discriminating		X										X
describing		X		X								
identifying and differentiating			X									X

TABLE 1 (cont'd.)

Process	Tannenbaum	AAAS	Shamos (COPES)	Jevons	Gagne	Curtis	Atkin	Conant	SCIS	ESS	Kessen	Keeslar
inducing and deducing			X									
hypothesizing			X								X	X
orienting				X								
making conceptual models				X								
reasoning					X							
drawing conclusions											X	X
recognizing and using numbers and number relationships		X										

possessed by secondary school pupils. The test consists of one hundred, fifty statements pertaining to the assumptions, activities, products, and ethics of science. Students express agreement or disagreement with each of the statements. The students' responses are assumed to indicate their knowledge of the idea contained in each of the statements. Student responses are keyed with a descriptive outline and on the opinions of fourteen research scientists. Total scores are calculated by adding the number of agreements with the standard key. The test was normed on one thousand, two hundred, eighty-three students in grades ten, eleven, and twelve. A reliability coefficient of .79 was found. The authors reported that the SPI discriminates in the expected directions when groups with suspected varying competency in knowledge of scientific processes are tested. This information lends support to the validity of the instrument.

The practical considerations of economy, convenience, and interpretability are of importance in the selection of appropriate test instruments. The SPI can be administered within a typical class period with the students completing the test in forty-five minutes. The test can easily be scored by hand or by machine scoring. It is also easy to administer in that administration directions are simple. Several limitations of the test were listed by the authors: (1) there is a possibility that removing a statement from the context of the descriptive outline may change its meaning or cause ambiguity; (2) expressing a topic as complex as science process in a language appropriate to high school students may change the original meaning; (3) the SPI is based on the authority of a sample of scientists. As such it may be valid for the opinion for this authority, but not valid for the opinion of all scientists. The controversial nature of the subject imposes restriction on the validity of the instrument. (Welsh and Pella, 1967, p. 67)

The Science Observation and Comparison Test (SOCS) by Hungerford and Miles (1969) is an instrument designed to measure the science process skills of observation and comparison. Although constructed for junior high school use, the authors believe it to be appropriate for intermediate grades as well. Students are required to make observations and comparisons on real scientific objects and to communicate their findings either orally, in writing, visually or a combination of these modes. On the observation portion of the test, students are asked to make an accurate visual reproduction of a particular specimen, noting structural details and labeling their drawings. Scoring on this portion is in three dimensions: (1) the excellence of the drawings, (2) the communication of morphologic features, and, (3) the labeling of structural parts. On the comparison portion of the test, only the ability to discriminate differences is required. A raw score of three is given for each reasonable and accurate comparison given by the student. The comparison part of the test can be used either independently or it can be added to the observation total for a grand total.

The test was piloted on eight heterogeneous seventh grade science classes. Interscorer reliabilities ranged from .83 to .94. Test-retest reliabilities, with a four-week delay, ranged from .39 to .68. Alternate form reliabilities ranged from .25 to .59. While this writer questions the value of these correlations, the test authors concluded that the SOCS Test can be scored reliably. They further state:

> The test-retest reliabilities, both with and without training, appear high enough to warrant

> use of the test for research and classroom purposes. The alternate form reliabilities for the most part seem high enough to warrant use of the two forms for pre-post type designs. (Hungerford and Miles, 1969, p. 65)

The validity estimate comparing the SOCS Test scores with teacher ratings yielded r's of .65, .43, .34, and .61. The authors concluded that the teacher ratings correlation and the increase in scores with training lend support to the validity of the test.

The authors give no information as to the practical considerations in using the test. It would appear that the testing time would vary considerably according to how quickly students draw the particular specimen. Certainly, scoring the test would take a large portion of time given the format of the test. Difficulty in scoring may be a problem in that there appears to be little in the way of a clear criterion reference.

The Science Process Instrument (SPI) by the American Association for the Advancement of Science was constructed to accompany the science curriculum, Science -- A Process Approach (S-APA). It attempts to ascertain the abilities of the learner in the following processes: observing, classifying, measuring, using numbers, using space/time relationships, inferring, communicating, and predicting.

The learner is presented with specified materials and is asked to perform a task reflecting one of the sequential behaviors cited. The learner's response is scored either as acceptable or non-acceptable by the examiner. The manual lists all acceptable responses. The administration of the test requires some special training. Extensive preparation is necessary in that the tester "must be thoroughly familiar with the format of the test, with the materials used, and with the method of scoring." (AAAS, 1968, p. 25)

This instrument was used as a research tool for phase I of S-APA and was terminated with the end of Phase I. Statistical data for the test were not published.

Test 9 of the Comprehensive Tests of Basic Skills, Expanded Edition, published by McGraw-Hill (1973) is a science test comprising thirty-six items designed to "assess a students' ability to investigate problems in science and, to a lesser degree, to recall scientific facts or concepts (Examiner's Manual, 1973, p. 5)." The skills enumerated are the abilities to classify objects, to measure or to quantify, to recognize a trend in data, to recognize a valid hypothesis drawn from presented data, and to analyze an experimental design. Level 2 is designed for grades 4.5 to 6.9. The emphasis in the process dimension is on the measurement of comprehension and application of concepts and principles rather than on the measurement of content.

Development of the CTBS was through generation of test items by teachers of appropriate grade levels, curriculum specialists and McGraw-Hill staff members. Reliability and norming data were amassed from eight thousand, six hundred students in 1972 and revised with additional samples to reduce racial and ethnic bias. Norms for a nationwide population are expressed as raw scores to grade equivalents, percentile ranks, and stanines in a CTBS Examiner's Manual. The Kuder-Richardson reliability for the test for grades 4, 5, and 6 are .79, .83, and .86 respectively.

The Science Process Test (TSPT) by Ludeman (1974) is designed to test students in grades six or seven on their ability to perform the four integrated science processes defined by the American Association for the Advancement of Science: formulating hypotheses, defining operationally, controlling variables, and interpreting data. The TSPT was developed by Ludeman, Fyffe, Robison, McLeod, and Berkheimer at the Science and Mathematics Teaching Center of Michigan State University. Copyright date for the test is 1974 and negotiations for commercial publication were not completed as of June, 1976.

The TSPT is a paper and pencil power test composed of thirty-six items inclusive of a test booklet and machine scoreable answer sheet. Ludeman found that students became restless and lost their concentration when the number of items exceeded forty. Content or face validity was replaced by a procedure known as external criterion references validation. Ludeman, et al. (1974) states:

> Using this procedure, items are included in the test on the basis of the requirement that children's performance on each item be highly correlated with their performance on the external criterion. (p. 2)

The external criterion for the TSPT is the Individual Competency Measures of Science -- A Process Approach. A major element in this design is the assumption that the Individual Competency Measures do, in fact, measure those processes. The correlation between the TSPT and the S-APA-ICM was .83 with an N of 52. The criterion for item selection for inclusion in TSPT was the requirement that: (1) all alternatives have been chosen by some students; (2) the context of the item allows its use, in some cases, since more than one item was based on a given context, the group of items had to be included or excluded in toto; (3) the difficulty of each item (proportion of students missing the item) was required to be between .2 and .7; (4) using the Individual Competency Measures scores to define the "upper twenty-seven percent" and the "lower twenty-seven percent" groups, each item was required to have a minimum discrimination of .2; (5) the correlation of students' scores on each item with their scores on the Individual Competency Measures was required to be .2 or greater. (Ibid., pp. 3-4)

Norming was conducted in the Spring of 1974 on one thousand, three hundred, one students from a random selection of twenty schools in Michigan and Indiana. There was a broad spectrum of science programs represented in the selection. Readability is cited at lower sixth grade level. The Kuder-Richardson reliability was given at .84. These tests represent the first attempts by the academic community to assess the processes of science.

The Test of Science Processes

The Test of Science Processes (TSP) by Tannenbaum (1968) is an instrument "to assess achievement and diagnose weaknesses in the use of science processes by students in grades seven, eight, and nine (Tannenbaum, 1968, p. 2). It consists of ninety-eight multiple choice, five option questions requiring a maximum testing time of seventy-three minutes, a test booklet which is printed in black and white, 35 mm color slides for the visual cues, and an answer sheet. (See the complete Test of Science Processes in the pocket of the thesis binding.)

Tannenbaum enumerated the unique science processes and the behaviors that seventh, eighth, and nineth grade students were expected to perform from a variety of grade level textbooks then currently in use. Curricular validity for the statement of processes was ascertained through twenty-two questions submitted to thirty science educators meeting any of several requirements of teaching experience, publications, recommendation by Columbia University faculty, and job description. This produced a final statement of fifty-three behaviors under eight processes and was used in his "blueprint" for the Test of Science Processes.

The "blueprint" for the TSP is a statement of philosophy supported by relevant literature and a listing of the processes and their assigned behaviors. A general philosophic summary of Tannenbaum's position is stated by the AAAS: (1) the scientists' behaviors in pursuing science constitute a highly complex set of intellectual activities which are, however, analyzable into simpler activities; (2) these intellectual activities (processes) are, as most scientists would agree, highly generalizable across scientific disciplines...; (3) these intellectual activities of scientists may be learned, and it is reasonable to begin with the simplest ones and build the more complex activities out of them, since this seems to be in fact the way they are organized (AAAS, 1965, p. 4). An abridged summary of the processes and their respective behaviors are shown in Appendix B.

On the basis of the "blueprint," Form I of the TSP was written comprised of ninety-eight multiple choice items; each item consisting of a 35 mm color slide visual stimulus, a mimeographed stem, and five choices. It was administered to 156 seventh, eighth, and ninth grade students in a Bronx, New York public intermediate school in January, 1968. An item analysis was performed and Form II was drafted:

> The ninety-six items and printed instructions were type written (with right-hand justified margins) and the color slides (except for those for questions one through twelve on Form II) were converted to tables or black and white prints. The correct answers to the items were randomized using a table of random numbers and the questions were arranged in a "saw-toothed" order of increasing difficulty within each subscore (based on the difficulty of the item when included on Form I). (Tannenbaum, 1968, pp. 57-58)

Form II was administered to three thousand, six hundred, seventy-three seventh, eighth, and ninth grade students from Rockland County and Bronx, New York in February, 1968. For each student, there were nine raw scores reported -- one for each subscore and one for total score. Scoring keys can be found in the pocket of the thesis binding. The complete results were used to determine the norms, item statistics, reliabilities, and validities and are described and reported in Tannenbaum's dissertation.

Reliabilities reported are the results of internal analyses of a single administration of the test using the Kuder-Richardson Formula 20. Test-retest correlations and alternate forms correlations were not obtained. Total score reliabilities are shown in Table 2. Process subscore reliabilities vary from a high of .82 to a low of .26. Tannenbaum recommends caution in the use of subscore reliabilities:

> It should be carefully noted by the user that while the total test and the longer subscores have adequate reliabilities, some of the shorter subscores have quite low reliabilities. This is

> almost surely due to their short length because their item-item and item-subscore correlations are high. However, due to the low reliabilities, only cautious use by trained personnel should be made of the shorter subscores. Of course, if in a particular administration, higher reliabilities can be demonstrated for the population under study, then this caution may be waved to the extent warranted by the new data. (Tannenbaum, 1968, pp. 103-104)

While the TSP is a power test, it is timed during administration. Tannenbaum states his position that:

> Although the test is timed during administration (cf., Instructions for Administration), this probably had a negligible effect on the performances of the students because: (1) the time limits were liberal enough to allow most (over 84%) of the students to finish, (2) all students were forced to attempt all parts of the test, and (3) if they finished early, students were allowed to go back and work on any question(s) which they skipped either because of difficulty or time limitations in a particular section. (Tannenbaum, 1968, p. 103)

TABLE 2

TEST OF SCIENCE PROCESSES
TOTAL SCORE RELIABILITY COEFFICIENTS

	SUBURBAN			URBAN			TOTAL		
RELIABILITIES	GRADE			GRADE			GRADE		
	7	8	9	7	8	9	7	8	9
TOTAL SCORE 96 ITEMS	.91	.91	.91	.90	.91	.90	.91	.91	.90

A review of the literature found a paucity of tests to assess the processes of science. The existent tests to date are summarized in Table 3, showing the grade levels for which it was designed, the reliability coefficient (Kuder-Richardson 20, unless otherwise noted), and the size of the norming population.

TABLE 3

SCIENCE PROCESS TESTS WITH ASSOCIATED GRADE LEVEL, RELIABILITY AND NUMBER IN NORMING POPULATION

INSTRUMENT	GRADE LEVEL	RELIABILITY	NORMING POPULATION
SPI	10, 11, 12	.79	1283
SOCS	5-9	.39-.68 Test-retest .25-.59 Alternate form	
SPI (S-APA)	Phase I Project terminated, data not released for publication		
CTBS	4, 5, 6	.79-.86	8600
TSPT	6	.84	1301
TSP	7, 8, 9	.91	3673

None of the process tests summarized are for the medium of television.

Television Testing

Little has been done in the way of formalized testing through the television medium. Perhaps the lack of usage can be accounted for by some previously encountered difficulties which can now be overcome by a better understanding of classroom educational television and by better technological innovations within educational television. In the past, teachers have reported that television receivers are unreliable, time schedules do not allow for television usage, programs do not fit into the curriculum or are not suited to their students, schedules of television programs do not arrive in time or do not arrive at all, the influx of "machines" may replace the teacher, and an insecurity may develop in the classroom teacher because of competing with the highly skilled television teacher. Administrators responding to a questionnaire which included the question: "Why do you not use the school's television service?" gave the following answers: (1) my staff are (is) not lazy; (2) my staff would become lazy; (3) my students would become lazy; (4) too much like entertainment; (5) there is no time to spare from teaching; (6) if you could cut out the films and photographs and just show a teacher with a blackboard; (7) if you could just send the script, we could do much more with the material than seeing it on television; (8) there is nothing you can give the students that I cannot (Combes and Tiffin, 1970, p. 71).

This opposition to television usage within the classroom has been overcome by equipment which is reliable and easy to use, teacher training which emphasizes a better understanding of educational television, and the development of video tape which allows the teacher to select appropriate lessons and time schedules.

Combes and Tiffin (1970) advocate the utilization of television for testing, suggesting the advantage of such a procedure of preventing the tendency of teachers to teach stock answers to stock questions. In listing the advantages of testing via television, Pessinger (1969) states:

> Close-ups showed important sections of the forms, and critical instructions received graphic emphasis. (p. 19)
>
> Video tape has improved San Jose's televised testing procedure because close-ups, such as those illustrated can be precisely composed and positioned in the program -- something not always possible in live production. Further, taped instruction can be re-used as often as necessary until there are significant changes in the instructions or the test forms.
>
> Over the years, televised testing procedures have been quite successful. Errors invariably made by students in marking answer sheets have been reduced. Use of video tape has increased these advantages -- facilities requirements and set-up time for the television staff have been materially reduced; standardization of instruction has been expanded from a 'room to room' basis to a 'testing date to testing date' basis, and test supervision has been improved by allowing the test officer to be in direct contact with testing rooms. (Pessinger, 1969, p. 20)

Gross (1969) makes a strong case for visual testing by pointing out that the student becomes visually oriented and learns the material by visual rather than verbal association by watching television. Thus, when the student is tested verbally on visually presented material, he becomes frustrated and his score on the test is not a true measure of what he actually knows. With the influx of more television teaching and the resultant new teaching concepts, Gross (1969) states:

> ...it appears obvious that the Dark Ages of testing should be abandoned in favor of techniques adapted to the new methods of learning. (p. 35)

After a television course in health education and an accompanying test via television, students were asked to comment on their reactions to visual testing. The following are typical reactions:

> I learned from the test, also, because of the pictures.
>
> I whole-heartedly hope that tests in schools will change to the type presented today. I usually hate tests, but I enjoyed this one. I get so tense that I forget what I have been taught. One of the benefits that can be derived from this kind of presentation is free time for the professor or time put to better use.
>
> I want you to know how much I enjoyed taking the midterm test Saturday, the 13th. The test was motivating. (Gross, 1969, p. 36)

Gross (1969) comments on the advantages and adaptability of television testing:

> Biology television courses could take full advantage of television's close-up properties for testing by projecting microscope slides and asking students to identify them. This would be far superior to paper and pencil questions such as 'describe an amoeba'. (p. 36)
>
> The sciences, including chemistry and physics, can also utilize television's visual properties by showing actual experiments and allowing students to analyze or hypothesize about them. (Gross, p. 38)
>
> ...visual testing need not be exclusively for televised courses. Any teacher who employs various visual aids to accomplish his teaching would be well advised to consider visual testing. (p. 38)

In a project reported by Thomas (1975), third, sixth, ninth, and eleventh grade students in American Samoa were tested via television on their listening comprehension of the English language. Television was chosen as the mode of testing because it saved time, reduced the number of testing personnel required, allowed for consistant pronunciation, and eliminated the problem of teachers helping students. Thomas (1975) states:

> The people involved in the experiment concluded that the videotape approach ~~and the~~ pictorial booklets provided a most satisfactory solution to the problem of group testing for pupils' understanding of a spoken second language. (Thomas, 1975, p. 27)

Hopkins, Lefever, and Hopkins (1967) compared scores of teacher-administered tests and television-administered tests. All the fifth and sixth graders in eleven experimental schools were given a standardized test (Metropolitan Science Test) via closed-circuit television while all other fifth and sixth graders of nine control schools were administered the same standardized test by an on-the-scene tester. The test was given the same day at the same hour. All of the students had received identical instruction in science via television since the beginning of the school year. Resulting scores indicated no significant differences in means for television versus teacher administration.

Project NuTEx is a program developed to administer the National Teacher Examinations via television (Landis, et al., 1971). This endeavor was prompted by recent but consistent criticisms concerning the heavy reading load imposed by the original test and the possible racial, regional, and class bias inherent in some of the test items. Videotape presentation allowed for stimulus control and environmental simulation which promised to be an improvement over the abstractions of the pure paper and pencil test. It was felt by the project participants that the use of classroom simulation scenes would do more equalizing for prospective teachers from disadvantaged or minority backgrounds. The verbal portion of the test was presented with white-on-black lettering appearing on the screen with voice-over reading of the item for dual emphasis. The second part of the test consisted of a series of classroom situations taken from actual classrooms, with questions suited to the situation. The authors of Project NuTEx comment about their development of television-based testing:

> One can project many fascinating possibilities, but the contribution that television will make toward improving our current evaluation procedures (the classroom behavior) rests on the degree to which long-time testing professionals, whose training and interest are now almost entirely centered on paper and pencil measures, become convinced that this new medium has merit. (Landis, et al., 1971, p. 20)

Test administration mode was investigated by administering a standardized achievement test (Gates Reading Survey) to eight hundred, eighty-two seventh grade students in four junior high schools (Munger, 1972). Half of the randomly selected students were given the test "live" and the other half were given the test by way of television. It was found that the mode of test administration had a significant differential effect on standardized reading test scores. The findings of the study concluded that students can be expected to earn higher reading scores when tested by an on-the-scene test administrator than when tested by videotape.

CBS-TV has produced a number of television tests such as The National Citizenship Test and The National Driving Test. The format of the programs basically consisted of short scenes demonstrating various activities. The narrator asks a question and then pauses for the home audience to respond. The correct answer is then given with an explanation as to why it is correct.

Studies have indicated that testing via television has several advantages over traditional modes of testing. Standardization of test directions is a major advantage. Also, for some content areas, television can show close-ups which emphasize critical visual information thus reducing errors in marking answer sheets. It adds the dimension of motion which traditional test modes cannot accomplish. Television tests can be administered to large groups at a minimal cost and the test can be used over and over.

Summary

A review of the literature found considerable support for the need to teach those skills and abilities employed by scientists and identified by psychologists and educators as science processes. However, no general agreement in the list of those skills and abilities was found. This imprecision was canoted in the Dictionary of Education which lists this open-ended definition:

> Process approach, an approach to science instruction in which children learn generalizable process skills that are behaviorally specific but which carry the promise of broad transferability across

> many subject matters; it adopts the idea that novel thought can be encouraged in relation to each of the processes of science, such as observation, inferrence, communication, measurement, etc. (Good, 1973, p. 439)

This ambiguity of terminology portends difficulty to the test developer who attempts to measure science processes. If no uniformity exists, the test developer must define those characteristics to be assessed by his unique instrument. This could result in a proliferation of instruments which measure unique factors wholly different from other instruments but are collectively labelled science process tests.

A survey of the literature found few tests of science process. Those reported on are: the Science Process Inventory (SPI), the Science Observation and Comparison Test (SOCS), the Science Process Instrument, the science subtest of the Comprehensive Tests of Basic Skills (CTBS), The Science Process Test (TSPT), and the Test of Science Processes (TSP). Each of these tests is designed for varying grade levels, ranging from fourth to twelth grade. None of the tests is for television presentation.

The literature revealed a scarcity of testing via television. Of the studies reporting on television testing, most have concluded that television presentation of tests has several advantages over traditional modes of testing. The literature suggests that testing can be effectively conducted through the medium of television.

CHAPTER III

PROCEDURE OF THE STUDY

Introduction

The procedure for modifying the TSP for the intermediate level and adapting it for television required the following steps: (1) present the question content of the Test of Science Processes to a panel of judges on elementary science curriculum and instruction to ascertain the content validity of the test as applicable to intermediate level students, (2) rewrite those questions recognized appropriate by the experts to conform to the readability adequate for upper elementary students, (3) produce a pilot test composed of the adapted questions on quadraplex video tape and produce the associated print materials, (4) provide a pilot exposure and techniques to ascertain appropriate test item exposure time, (5) edit the video production to conform to the time data, (6) provide a pilot run of the televised test to a large number of students to amass data for item analysis, (7) establish statistical parameters by which the item analysis would provide a refinement of those questions which would comprise the final form of the test and edit the video production accordingly, (8) provide for broad exposure of the test to ascertain norms for target populations; and (9) provide an experimental study to amass concurrent and predictive validity data.

Establishing Content Validity

Content validity was established by subjecting the ninety-six questions of the TSP to a critical analysis by a panel of judges in elementary science at The Pennsylvania State University. (See Appendix D for panel of judges.) The questions were reviewed: (1) to identify content applicability for measuring process skills at the intermediate level with minor revision and (2) to sample the eight processes identified by Tannenbaum -- observing, comparing, classifying, quantifying, measuring, experimenting, inferring, and predicting. Whereas the questions were identical or similar, content validity could be partially inferred through the "blueprint" data of Tannenbaum. On the basis of the initial selection, the questions for Form A of The Television Test of Science Processes were identified.

Readability Considerations

Once the applicable questions were identified as having content validity for the proposed target audience, a revision of vocabulary and syntax of the verbal message was necessary to effect content validity for the intermediate level. Three one-hundred word randomly selected samples of the Test of Science Processes were subjected to the Graph for Estimating Readability (Fry, 1968) in order to ascertain the difficulty level of the original questions. Since the Test of Science Processes was constructed for use with junior high school students, it was necessary to revise the selected questions in order to reduce the reading difficulty of the test. This was accomplished by shortening sentence lengths and by altering the vocabulary. A certified reading specialist modified the vocabulary by replacing the difficult words with easier to read synonyms judged by her to be appropriate for elementary school aged students. The verbal message was evaluated through the use of the Graph for Estimating Readability and through the use of the Syntactic Density Score by Golub (1973) to ascertain the reading difficulty of the revised questions. These two readability instruments were selected to ensure a comprehensive evaluation of the verbal component of the test. The "Fry Formula" measures readability in terms of sentence length and difficulty of words. The Syntactic Density Score reflects the relative complexity of the sentence structure.

All written material in sentence form which the students were required to read was analyzed. Twenty-six one-hundred word samples were counted out and the number of sentences and syllables were computed for each sample. Averages for sentence length and number of syllables was determined and then plotted on the Graph for Estimating Readability to find the reading level.

Research has upheld the "Fry Formula" to be a useful tool in estimating readability. Fry developed his formula by assigning grade level designations by plotting a great number of books which publishers had said were of a certain grade level. Fry then looked for clusters and "smoothed the curve." After the formula was applied and correctional studies made, the grade levels were adjusted. The formula judges difficulty on the basis of sentence length and word length in terms of syllables. A comparison is made of sentences per one-hundred words. Validity of using sentence length and number of syllables to determine readability has been investigated by Stolurow and Newman (1959).[1] They found a high correlation (.90) between easy words and monosyllabic words and reading ease. Average sentence length correlated .86 with difficulty. Their conclusion was that any yardstick which gave primary weight to the sentence factor would account for a good deal of the variance in readability.

Rank order correlations between the Fry readability graph and the Spache (1953) formula for seven primary books was found to be .90. Correlations for the upper range of the Graph for Estimating Readability and other readability measures are as follows:

Dale-Chall Formula	.94
Flesch Formula	.96
SRA Reading Ease Calculator	.98
Botel Formula	.78

The Syntactic Density Score was obtained by subjecting all answer choices in sentence form to computer analysis using the Syntactic Density Program at the Computer Center of The Pennsylvania State University.

Golub's Syntactic Density Score is a measure of readability which reflects the quantitative and qualitative grammatical structures of a given selection of written material. Golub and Kidder (1973) state:

> The syntactic density of a child's or student's spoken or written language, when compared to other children his age, should indicate normative syntactic language development. (Golub and Kidder, 1973, p. 1)

The Syntactic Density Score was developed by sampling children's syntactic structures in oral and written discourse. Teacher ratings of high, medium, and low were then made on the samples. Twelve variables of syntactic structures were identified which correlated significantly with teachers' judgments of the written language samples. "Through a process of canonical correlation analysis, relative weights were assigned to each variable according to its contribution to a factor named 'syntactic density'." (Ibid. p. 2)

The Syntactic Density Score reflects the measure of: (1) T-unit length (one main clause and its related words, phrases and clauses), (2) subordinate clause length, (3) use of complex verb phrase expansions, (4) use of some advanced structures of time, and (5) reductions or embeddings that take the form of prepositional phrases. It does not account for vocabulary intensity. The tabulation of Golub's Syntactic Density Score has been programmed for the computer.

Television Production of the Test Instrument

After selection of the test questions and the modification of the verbal message for readability considerations, the next step was to adapt this visual and verbal information for television production. The first phase of the TV production involved the development of a TV script that best presented the verbal and visual information. It was decided not to use the existing 2x2 slides through the TV multiplexer system. Direct video tape recording (VTR) of the visuals was chosen because of several advantages: (1) the advantage of superior lighting, (2) it was less expensive in that the cost of the slide processing was eliminated, (3) the dimension of motion could be added, and (4) graphics could be managed electronically. Most important is that direct recording provides a better quality visual than does slide transfer.

Phase I required the drafting of a TV format script, design and development of the graphic visuals, the procedures for the logistics of assembling the visual materials, and the scheduling of the TV studio and personnel for the video taping sequence. Items employed for the visual presentation of the questions were selected from the Science Education store of materials of The Pennsylvania State University and assembled in the studios of WPSX-TV, the public television station of The Pennsylvania State University. Graphic art was produced in the graphics service unit of the Division of Broadcasting of WPSX. Form A of the TTSP was recorded on two-inch quadraplex tape of broadcast quality on an RCA TR70 unit with Norelco color cameras. Efforts were made to control all visuals for effectiveness and for contrast in color and in the gray scale. Question numbers with a special-effects "wipe" introduced each question visual. The decision was made to verbally state each question and leave the question on the screen for ninety seconds. This was to allow completion of every question for the item-response-time study cited next. Completion of Phase I formed Form A of the TTSP.

The television crew for all phases of the production consisted of the professional staff of WPSX-TV comprised of Gary Perdue, producer-director; Steve Hubicsak, editorial assistant and narrator; and this writer serving as associate producer and production assistant. Also included was a switcher, two engineers, three cameramen (one each for graphics, live action and superimposition), and several production assistants.

Phase II required an edit of the Phase I tape to conform to the times established in the item-response-time study. Completion of Phase II formed Form B of the TTSP. An introduction to prepare students to take the test via television was developed for a two-part presentation.

Phase III followed the item analysis of the test results of the Form B exposure. This included a final edit and the summary graphics. There were several technical considerations involved. Total test time was to be two one-half hour programs to conform to broadcast schedules. This was to be short enough to maintain student attention, yet long enough to cover the material. Narration had to be held to the reading of the questions. Narration of the answer choices was dismissed because of the time involved and the confusion it created with verbal discrimination. Sufficient time to react to the question controlled the narration time. The total verbal information utilized was the necessary introductory comments and directions for test taking and the narration of the test questions which provided for cross channel redundancy (Hsia, 1968; Hsia, 1969) to reduce equivocation. This formed Form C of the TTSP final product.

Item-Response-Time

Because the TTSP is a power test and because the television modality via the broadcast channel is uncontrolled by the test administrators once the video taped package was completed, it was necessary to administer a pilot test and gather information on the appropriate amount of time necessary to maximize the exposure time of the visuals to the students while minimizing the television time. The ninety-second constant exposure was wasteful in both student time, production costs, and broadcast costs. Optimum test response time was necessary.

The traditional way to measure speediness is to set a fixed time limit for the total test and then see how many questions (out of the total) were responded to by, for example, ninety percent of the examinees. Based on this, either time limits are adjusted or the number of items is altered.

In the present study, however, since television broadcast time was involved, it seemed more appropriate to empirically determine how much time it took, i.e., the ninetieth percentile, for examinees to respond to test items.

The entire fifth grade class of the Centre Hall School, comprising sixty-eight students, of the Penns Valley School District, Pennsylvania of predominantly rural background were administered Form A of the TTSP via closed-circuit TV. Four graduate students of the Department of Academic Curriculum and Instruction of The Pennsylvania State University observed the test administration, each observing a defined group. Using a stop watch, they noted the time in seconds from the end of the verbal message on the test to the final mark on the answer sheet required for each student in their defined groups to answer the question. This included the time for some changes of answers and erasures. The item-response-time data was tabulated. The mean and standard deviation for each item was computed.

Helmstadter (1964) states:

> ...where practical considerations do not limit the time, the test length will be determined by the number of items required to achieve as high a degree of validity as possible without exceeding the point where costs in terms of time, effort, money, and patience of the examinee outweigh the additional gain. Time limits of such a test are usually taken so that approximately ninety percent will be able to finish. (p. 173)

It is clear that setting the number of items on the test based on how many ninety percent respond to is not an equivalent procedure to setting time limits per item based on the ninetieth percentile for times taken on that item. However, using the ninetieth percentile of the times for each item was thought to be a reasonable way to best approach the traditional speediness measure for applications to television testing. The video tape of Form A of the TTSP was then edited to conform to the recommended times to form Form B.

Item Analysis

To derive a pool of questions that were applicable for use at the intermediate level, Form B of the TTSP was administered as a pilot test to a large sample of fifth and sixth grade students. A contact was made through the Department of Education for a pilot test to be administered in a large suburban Philadelphia school system. The Marple-Newtown School District was utilized as a test group. One hundred and sixteen fifth and sixth grade students were exposed to the test instrument via closed-circuit television under controlled conditions at the Brown and Culbertson Schools in December, 1974.

The criterion for time inclusion was: (1) a difficulty index ater than .35 and less than .85 and (2) a point biserial corre- ion greater than .20. These criteria are suggested by Kelly (1939). the sub-processes identified by Tannenbaum were to be sampled. m this pool, 40 items were to be identified and incorporated into m C of the TTSP.

ming

To collect norming information, it was necessary to expose the evision Test of Science Processes, Form C to a large sample of dents. During October of 1975, the TTSP, Form C was broadcast over X-TV, Channel 3 of the Pennsylvania Public Television Network. In peration with the Allegheny Educational Broadcast Council, nineteen ool systems cooperated in the collection of norming data in a umented effort during this time sequence. The TTSP was scheduled part of the total SFTS public presentation on television station X-TV. An alternating schedule to allow for ease in public school eduling is the rule for all SFTS programming. A total of 3480 fifth de students were given the test instrument under normal classroom ditions of television viewing and test taking. Table 4 lists the ool districts in alphabetical order with the number of participating dents; information relative to their rural, urban, or suburban ssification; grouping; and a statement of their present science ching methods. The descriptive information of the district in le 4 is quoted from correspondence from officials of the various tems and do not represent an objective statement by this writer.

TABLE 4

SUMMARY INFORMATION OF SCHOOL DISTRICTS PARTICIPATING IN NORMING SAMPLE

School District	Students	Rural/Urban	Grouping	Science Program
1. Altoona Area	750	predominantly urban	heterogeneously	stresses both content and processes
2. Bald Eagle Area	245	predominantly rural	heterogeneously	utilizes 'hands on' science instruction
3. Bellefonte Area	233	semi-rural	heterogeneously	using a predominantly traditional approach in science
4. Berlin Brothersvalley Area	74	rural	homogeneously	using traditional methods
5. Brookville Area	190	rural	heterogeneously	using the SCIS program
6. Clarion-Limestone Area	82	rural	heterogeneously	utilizing the Science Curriculum Improvement Study (SCIS)
7. Curwensville Area	138	predominantly rural	heterogeneously	use the SAPA program in grades K-3 and employ developed Mini-Science courses in grade 5 (Team Taught)
8. Indiana Area	318	evenly distributed across a rural to urban spectrum		employing an inquiry oriented science program
9. Lock Haven Catholic School	21	mostly urban		using a textbook series supplemented with SRA Labs
10. Northern Bedford Area	104	rural	heterogeneously	using the Rand McNally ESLI science program supplemented with ESS kits
11. Punxsutawney Area	133	basically rural	heterogeneously	using a student laboratory approach in the elementary science program
12. St. Francis School, Clearfield	21	suburban	heterogeneously	using a traditional approach
13. St. Peter's School	25	rural	homogeneously	utilizing the Cambridge Textbook series
14. Shade-Central City Schools	83	predominantly rural	heterogeneously	employing the <u>Concepts in Science</u> textbook series supplemented with ETV
15. Spring Grove Elementary School	149	mostly rural	heterogeneously	two classes employing a modern science approach with the third using a traditional approach
16. Union Area	82	predominantly rural		using the SCIS program
17. Warren County	450	mostly rural	heterogeneously	uses Heath Series supplemented with ESS program
18. Westmont Hilltop Area	172	suburban	heterogeneously	using the SCIS program
19. Williamsport Area	209	mostly urban	heterogeneously	employing SAPA

Figure 1 shows a map of the location of the participating school districts. Complete documentation of the broadcasting procedural experience inclusive of the initial public relations contacts through final correspondence is cited in Hill (1976).

Reliability

In cooperation with the Elementary Supervisor of the Lewisburg Area Public School District, Pennsylvania, an effort to collect reliability and validity data for the TTSP was undertaken. Form C of the TTSP was administered to the fifth and sixth grade students in four schools of the Lewisburg Area Public School System during March of 1975. In October of 1975, an item analysis of the norming study data yielded reliability information for the 3480 fifth grade students involved. Reliability is the result of internal analysis using the Kuder-Richardson Formula 20.

Validity

Empirical validity is inferred through the relationship that exists between scores on the TTSP and other tests of science processes.

> ...empirical validity provides the evidence that a test score can be interpreted in a particular way by showing that a relationship exists between the test performance on the one hand, and on the other, behavior in some second (criterion) activity. (Helmstadter, 1964, p. 112)

In May of 1975, all of the fifth grade students at the Lewisburg Area School District were administered the McGraw-Hill Comprehensive Tests of Basic Skills inclusive of Test 9, the Science Test. This was

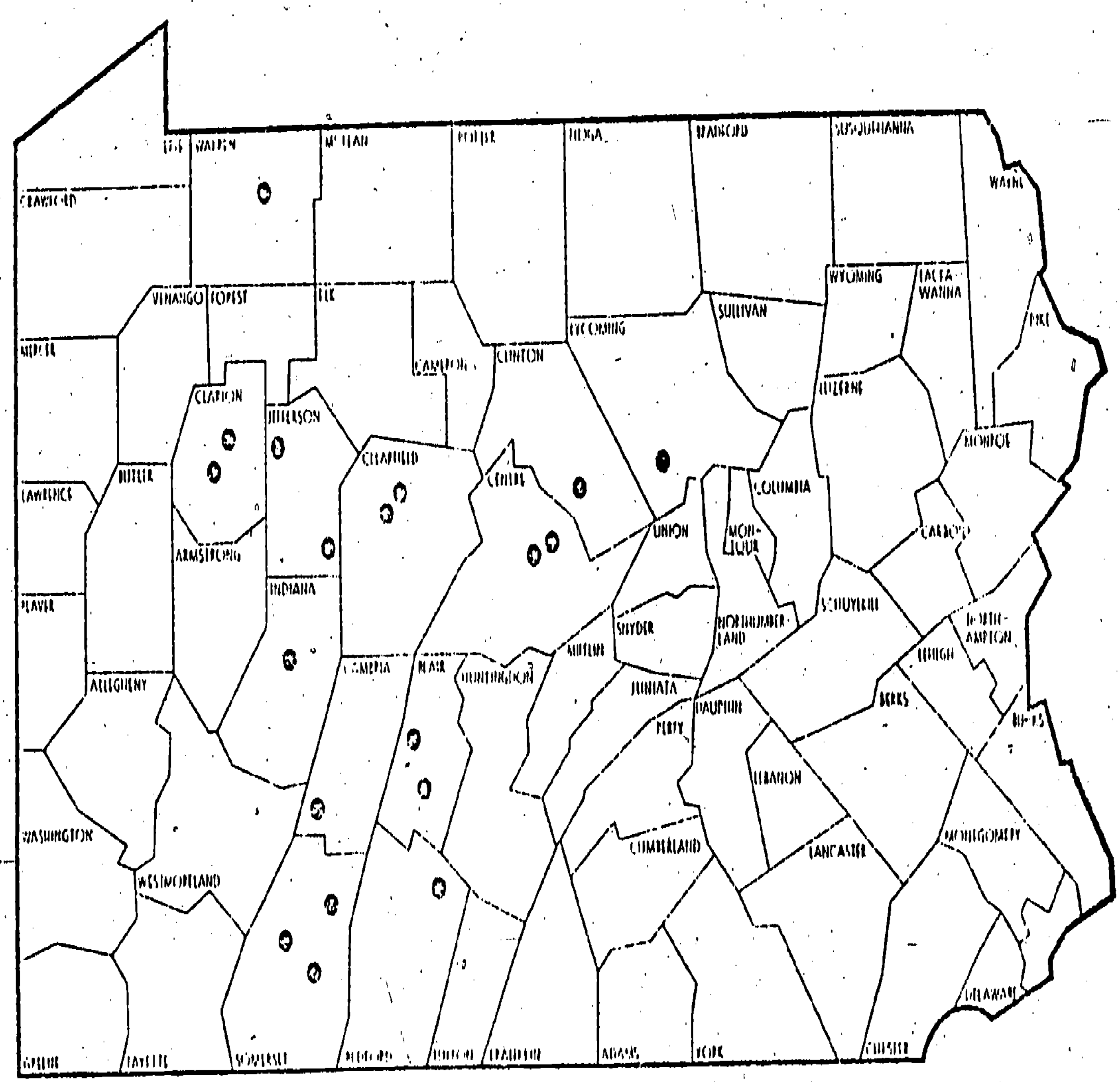

Figure 1: Geographical Distribution of Participating School Districts and Schools in the Norming Population

art of a total achievement testing program. During February, 1976, all of the sixth grade students (the former fifth grade students mentioned above), numbering 207, were administered The Science Process Test (TSPT). Data from all three tests with additional pertinent data (summarized in Appendix N) was compiled. The information was placed on computer data cards and a Pearson product-moment correlation data matrix was generated to assess inter-correlations.

Whereas the CTBS scores were within a short time frame with the scores of the TTSP, nearly one year elapsed between the scores of the TTSP and TSPT. During this time, the fifth grade students were moved to the "Middle School" environment. Ary, et al. (1972) states:

> Except for the time dimension, concurrent validity and predictive validity are very much alike. In predictive validity, the relationship between the scores of individuals in a test of performance in a future task is determined; whereas in concurrent validity, the relationship between the test scores and a present criterion is sought. (p. 195)

On this basis, a statement of concurrent validity was inferred from the correlation between the TTSP and the CTBS Science score and a statement of predictive validity was inferred from the correlation between the TTSP and TSPT. These data are summarized in Chapter 4. Additional correlational data and their implications are discussed in Appendix N.

CHAPTER IV

RESULTS

Introduction

This chapter summarizes the results of this study for the various steps involved in the modification of the TSP for the intermediate level and adapting it for television. The procedures for the various steps involved are described in Chapter III. For convenience, information shown on computer printouts is summarized and abbreviated in this chapter. Photo reductions of complete computer printouts are cited and shown as Appendices.

Establishing Content Validity

After critical analysis of the ninety-six questions of the TSP by the panel of judges in elementary science at The Pennsylvania State University, sixty-eight questions of the original ninety-six were identified as applicable to the intermediate level curriculum and eligible for revision and inclusion in a pilot test to provide further data. The questions recommended are shown in Table 5. See the pocket of the thesis binding for the Test of Science Processes test booklet. This selection included six questions in Tannenbaum's process I (observing), five in process II (comparing), eleven in process III (classifying), eleven in process IV (quantifying), fourteen in process V (measuring), eight in process VI (experimenting), seven in process VII (inferring), and six in process VIII (predicting).

TABLE 5

TEST OF SCIENCE PROCESSES' QUESTIONS IDENTIFIED AS APPLICABLE FOR INCLUSION IN THE TTSP

Question Numbers							
1	11	22	31	40	56	69	84
2	12	23	32	41	59	71	86
3	14	24	33	43	61	72	87
4	16	26	34	44	62	73	88
5	17	27	35	45	63	74	89
7	19	28	36	49	64	75	90
9	20	29	38	52	66	76	92
10	21	30	39	53	67	78	94
				54	68	79	96

To maximize the accuracy of the question data, the positions of the correct answers on the answer sheet was found by employing randomizing techniques from a table of random numbers.

Readability Considerations

In order to ascertain the reading difficulty level of the Test of Science Processes, a random selection of questions was subjected to the Graph for Estimating Readability. A readability of sixth grade level was found.

After selection of questions identified for inclusion in the pilot Television Test of Science Processes, the verbal information of those questions was modified in an effort to reduce their reading difficulty. These modified questions were subjected to two readability measures in March of 1975. The Fry Graph for Estimating Readability was utilized to compute reading difficulty. A readability of third grade was found.

A readability level was interpolated for the data at high second-low grade level using the Syntactic Density Score. The complete computer printout is shown in Appendix E.

Television Production of the Test Instrument

Following the identification of applicable questions and the modification of the verbal message, the visual and verbal information of the selected questions was adapted for television presentation. Phase I of the television production was executed on August 6, 9, and 14, 1974. See Appendix F for a complete display of the visuals which form the TTSP, Form C.

Phase II of the television production took place on October 14, 1974. This involved editing the TTSP, Form A tape to conform to the time requirement of each question found in the item-response-time study cited in Table 6. The script for this introduction was developed and is shown in Appendix G. The complete test booklet for the sixty-eight questions comprising Form A and B is shown in Appendix H.

After an item analysis of the test results of the Form B exposure, Phase III of the television production took place on March 27 and 29, 1975. This consisted of revamping the entire Form B tape to eliminate and modify the questions in response to the data found in the item analysis, to renumber the selected questions, and to add the summary graphics. The final edit formed Form C of the TTSP. See Appendix I for the complete test booklet.

Item-Response-Time

A pilot test of the TTSP was administered in September, 1974 to gather information on the appropriate amount of time necessary to maximize the exposure time of the visuals to students while minimizing the television time. Graduate students of The Pennsylvania State University, Department of Curriculum and Instruction recorded the time in seconds required for each student to respond to each question.

Following the pilot exposure, the findings were tabulated and the total question item-response-time was calculated. Table 6 is a summary of the item-response-time of the ninetieth percentile of the total time required for each question. This data formed the editing time for production of the TTSP, Form B.

Item Analysis

Form B of the TTSP was administered as a pilot test to collect statistical data for item analysis. The data was processed by computer using the Item Analysis Data Program of the Examination Services of the

TABLE 6

SUMMARY OF THE TIME IN SECONDS ALLOCATED FOR EACH ITEM

Question Number	Test-Item Time	Question Number	Test-Item Time
1	22	35	22
2	42	36	40
3	41	37	31
4	37	38	36
5	39	39	25
6	35	40	30
7	37	41	20
8	34	42	26
9	43	43	35
10	55	44	48
11	31	45	19
12	36	46	40
13	25	47	26
14	28	48	34
15	45	49	43
16	35	50	35
17	39	51	22
18	44	52	45
19	29	53	37
20	40	54	35
21	58	55	37
22	54	56	22
23	55	57	20
24	34	58	30
25	20	59	45
26	23	60	44
27	29	61	40
28	33	62	30
29	27	63	30
30	47	64	25
31	40	65	25
32	30	66	36
33	16	67	34
34	17	68	22

University Division of Instructional Services, The Pennsylvania State University. This program includes item frequency/percent, difficulty index, biserial correlation, point biserial correlation, T-Value, and mean score of item responses. Table 7 is an abbreviated item analysis incorporating the difficulty index and the point biserial correlation for the total pilot test. The complete item analysis computer printout is shown in Appendix J.

Items were selected for further use which fell within the established guidelines. Some items were selected where either the difficulty index or the point biserial correlation was very close and the corresponding index or correlation was thought to be sufficiently strong to warrant its inclusion in the question pool.

Norming

Norms for the Television Test of Science Processes are shown in Table 8. This table is a photo reduction of the computer printout. Data is reported by raw score, percentile, and T-score. The T-score is a standardized score with a mean of 50 and a standard deviation of 10, not normalized. It also shows the frequency of items and frequency distribution. This format for recording is simple to read and for performing additional statistical manipulation. The numbers in the "Score" column are the raw scores on the test, the number correct; the "T-score" column is the standard score with mean = 50 and standard deviation = 10; the "Centile" column is the cumulative percent of the number of students scoring below the given raw score; and the

TABLE 7

SUMMARY OF ITEM ANALYSIS

Question Number	Difficulty Index	Point-biserial Correlation	Question Number	Difficulty Index	Point-biserial Correlation
1	.974	.258	* 35	.957	.226
2	.181	.126	* 36	.690	.282
3	.638	.005	37	.552	.257
4	.853	-.081	38	.216	.160
5	.836	.186	* 39	.586	.354
*6	.724	.387	40	.241	-.056
7	.129	-.256	* 41	.914	.338
* 8	.216	.240	* 42	.207	.421
* 9	.397	.249	* 43	.500	.415
*10	.422	.259	* 44	.397	.407
*11	.526	.414	* 45	.716	.338
12	.578	.186	* 46	.474	.253
*13	.767	.360	* 47	.491	.361
*14	.603	.291	* 48	.653	.597
*15	.474	.359	* 49	.629	.321
16	.922	.163	*50	.733	.258
17	.871	.192	51	.586	.197
18	.414	-.032	*52	.569	.485
19	.888	.099	*53	.552	.517
20	.862	.109	54	.103	.180
* 21	.776	.297	55	.397	.245
* 22	.474	.216	56	.353	.162
* 23	.810	.425	*57	.517	.249
24	.948	-.023	58	.440	.088
25	.810	.110	*59	.491	.404
* 26	.647	.464	*60	.586	.374
27	.664	.128	61	.362	.120
28	.957	.070	62	.293	.033
29	.474	.190	*63	.690	.628
30	.897	.195	*64	.310	.422
* 31	.560	.325	*65	.474	.354
* 32	.819	.378	*66	.552	.449
* 33	.922	.311	*67	.397	.307
* 34	.966	.178	*68	.586	.447

* Asterisk denotes questions selected for inclusion in Form C

TABLE 8

TABLE OF EQUIVALENTS AND FREQUENCY DISTRIBUTION OF NORMING SAMPLE

EACH SCORE REPRESENTS 0.03 PER CENT OF THE DISTRIBUTION

*** WARNING SCORE FREQUENCIES EXCEED MAXIMUM PLOTTING LIMITS.
*** THE KURTOTIC PROPERTY OF THIS GRAPH IS THEREBY DISTORTED

SCORE	T-SCORE	CENTILE	FREQ	DISTRIBUTION (EACH X = 5 SCORE/S)
1	22	1	2	Ix
2	24	1	4	Ix
3	26	1	5	Ix
4	28	1	12	Ixx
5	30	1	21	Ixxxx
6	31	2	40	Ixxxxxxxx
7	33	3	68	Ixxxxxxxxxxxxx
8	35	5	78	Ixxxxxxxxxxxxxxx
9	37	8	116	Ixxxxxxxxxxxxxxxxxxxxxxx
10	39	12	143	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxx
11	41	16	166	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
12	43	23	244	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
13	44	30	248	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
14	46	37	232	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
15	48	45	274	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
16	50	53	252	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
17	52	63	253	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
18	54	67	223	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
19	56	73	156	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
20	58	78	112	Ixxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
21	59	83	134	Ixxxxxxxxxxxxxxxxxxxxxxxxxxx
22	61	87	110	Ixxxxxxxxxxxxxxxxxxxxxxx
23	63	89	73	Ixxxxxxxxxxxxxx
24	65	91	75	Ixxxxxxxxxxxxxxx
25	67	93	61	Ixxxxxxxxxxxx
26	69	95	49	Ixxxxxxxxx
27	71	95	47	Ixxxxxxxxx
28	73	97	33	Ixxxxxx
29	74	98	22	Ixxxx
30	76	99	14	Ixx
31	78	99	10	Ixx
32	80	99	4	Ix
33	82	99	3	Ix
34	84	99	1	Ix
35	86	99	2	Ix
36	87	99	2	Ix
37	89	99	0	I
38	91	99	1	Ix

TOTAL 3480

frequency of each raw score. A complete item analysis is shown in Appendix K. A summary of the statistical data obtained from the administration of Form C of the TTSP is shown in Table 9.

Reliability

Reliability was ascertained through internal analysis using the Kuder-Richardson Formula 20 (KR-20). Data for the reliability investigation was collected and transposed to EDP cards and processed at the Computer Center of The Pennsylvania State University using the Item Analysis (ITAN1) Program of the University Examination Services.

The KR-20 reliability coefficient for the fifth grade students which comprised the norming study was .736. Table 9 shows the summary of the statistics for the norming sample of the TTSP, Form C. A complete computer printout of the item analysis is shown in Appendix K.

The KR-20 reliability coefficient for the fifth grade students which comprised the validity study was .816. Tannenbaum cites average KR-20 reliabilities for the TSP at grades 7, 8, and 9 at .91. Using the Spearman-Brown Prophecy Formula (Nunnally, 1967; Helmstadter, 1964) to adjust for test length, the estimate for the reliability of the TTSP for ninety-six questions is .91. Table 10 shows the summary of the statistics for the validity sample on the TTSP, Form C. A complete computer printout of the item analysis, table of equivalents and frequency distribution is shown in Appendix L.

TABLE 9

STATISTICS FOR THE NORMING SAMPLE ON THE TTSP, FORM C

Grade level	5
Number of students	3480
Mean score	15.96
Standard deviation	5.35
Standard error of measurement	2.75
Mean point-biserial	0.294
KR-20 reliability	0.736
Mean difficulty	0.399
Test range	38
Standard error of test mean	0.09
Skewness	0.39
Kurtosis	3.21

Validity

Data for the validity investigation were collected and transposed to EDP cards and processed at the Computer Center of The Pennsylvania State University in March, 1976 using the Pearson product-moment coefficient (PPMCR) of the Statistical Package Program of the University Examination Services.

The PPMCR computes a Pearson product-moment correlation coefficient for every possible pair of input variables and also prints the mean and standard deviation of each input variable. The output is produced in a form which can be used as input to other Statistical Package programs such as Factor Analysis and Regression. The output may be passed to a subsequent program for further analysis. Options are provided to allow incomplete or missing data. Fourteen variables were correlated for the purposes of providing additional information for this study and for related investigations in progress at this writing. The complete computer printout is shown in Appendix M.

TABLE 10

STATISTICS FOR THE VALIDITY SAMPLE ON THE TTSP, FORM C

Grade level	5
Number of students	203
Mean score	18.86
Standard deviation	6.29
Standard error of measurement	3.03
Mean point biserial	0.352
KR-20 reliability	0.816
Mean difficulty	0.497
Test range	29
Standard error of test mean	0.44
Skewness	0.31
Kurtosis	2.38

TABLE 11

SUMMARY OF PPMC OF FIFTEEN VARIABLES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 TTSP Total	1.00														
2 TTSP Class Sub.	.172	1.00													
3 TSPT Total	.658	.098	1.00												
4 TSPT Time	-.043	-.025	.052	1.00											
5 SFTAA Verbal	.552	.086	.770	-.121	1.00										
6 SFTAA Non-Verbal	.626	.184	.720	-.043	.664	1.00									
7 SFTAA Total	.641	.139	.813	-.093	.929	.888	1.00								
8 CTBS Rdg. Vocab.	.620	.083	.779	-.139	.864	.653	.842	1.00							
9 CTBS Rdg. Comp.	.611	.038	.749	-.114	.801	.643	.800	.850	1.00						
10 CTBS Lang. Total	.645	.093	.737	-.127	.774	.665	.796	.822	.800	1.00					
11 CTBS Math	.653	.064	.770	.091	.710	.789	.812	.753	.746	.792	1.00				
12 CTBS Science	.660	.073	.761	-.043	.755	.723	.813	.775	.783	.737	.764	1.00			
13 CTBS Soc. Stud.	.634	.071	.783	-.040	.791	.720	.831	.819	.805	.791	.768	.773	1.00		
14 Rpt. Card	.570	.148	.690	.086	.593	.650	.669	.646	.610	.642	.681	.603	.630	1.00	
15 OTIS I.Q.	.527	.368	.822	-.095	.772	.774	.853	.796	.715	.772	.855	.740	.741	.547	1.00

The correlation between the TTSP and the TSPT in this study was .66. The correlation between the TTSP and the Science Test of the CTBS was .66. Both correlation coefficients are significantly different from zero at the .01 level. The summary of the Pearson product-moment correlation of fifteen variables is shown in Table 11.

CHAPTER V

SUMMARY AND CONCLUSIONS

Introduction

There were two objectives in this study: (1) to modify the Test of Science Processes by Tannenbaum (1968) for use by intermediate level students, and (2) to adapt the test for use through the medium of television. Information generated in this endeavor included that which was necessary for the modification and adaptation of the Tannenbaum instrument as well as spurious information recommending further inquiry.

Summary

This was a developmental study in which a normative test to assess performance in the use of certain of those skills and abilities identified as science processes by intermediate level students through the medium of television was created through the modification and adaptation of an existing normative testing instrument. The steps involved were to develop an item pool consisting of those questions from the Test of Science Processes which were representative of the science processes and were applicable for intermediate level students; to rewrite the selected questions so as to make them more easily read by intermediate level students; to produce a pilot test; to provide a pilot exposure to ascertain test item exposure time; to edit the video tape for appropriate timing; to pilot the test on a large population to amass data for item analysis; to develop the final form of the test by selecting questions appropriate through statistical parameters set by performing an item analysis; to provide a broad exposure of the test to ascertain norms for target populations; and to provide an empirical study to gather concurrent and predictive validity data. The steps have taken into account or considered the standards of the American Psychological Association (1974) for test developers of educational and psychological tests. The following is a summary of those activities that were necessary to complete this study.

An item pool was generated from the ninety-six items of the Test of Science Processes which were a representative sample of the eight science processes identified and defined in Appendix B and applicable for the intermediate level with minor revision. These questions were chosen on the basis of their requiring the skills and abilities recognized as process skills and on the basis of their applicability to intermediate level students. The question selection was performed by a panel of elementary science educators of The Pennsylvania State University whose credentials reflect a high degree of experience in research and teaching and are recognized both nationally and internationally as possessing a high degree of expertise by the academic community.

After the item pool was identified, an implementation procedure was pursued to produce the print and non-print components to form a prototype Television Test of Science Processes. The print component consisted of a television test booklet and teacher's manual. It involved a careful review of the verbal component, the visual digital information (Knowlton, 1964; Conway, 1968), modification of the test items' vocabulary and syntax to conform to a readability level applicable to the intermediate level. The modified verbal message was subjected to two readability measures to ascertain its appropriateness for the target population. This was performed and the resultant study found both vocabulary and syntax to be appropriate. The results are cited in Chapter 4 under "Readability considerations." Question answers and distractors were scrambled in a random manner using a table of random numbers for answer placement. Upon completion of the total print message, it was organized and printed in the format of the Test of Science Processes.

The non-print component was reviewed and organized in a television script into the audio and visual modes. It was decided that the narration of the questions and the answers were too time consuming and were distracting. The visual information was reviewed for optimal television presentation. For clarity of visuals, implementation of motion where appropriate, cost considerations, and production techniques, it was decided to record all visual information on two-inch video tape of broadcast quality. Using the production studio of WPSX, the entire verbal and visual information was produced. After an introduction and directions for taking the test, the question visuals and question narration preceded by the appropriate number were recorded for each of the sixty-eight questions of the identified item pool. From the end of the narration to the next item, visuals were shown for ninety seconds. This video tape package combined with the print component formed Form A of the Television Test of Science Processes, the prototype or research instrument for further study.

To ascertain the appropriate timing for each of the visuals, Form A of the TTSP was subjected to an item response time study. A population of central Pennsylvania fifth grade students were identified and given Form A of the instrument. Graduate students of The Pennsylvania State University recorded the times for each student to respond to each question inclusive of corrections. Using the rule of the 90th percentile, a cutting time was identified for each question. The video tape was edited to conform to the appropriate times. Results of the item-response-time study are cited in Chapter 4. The edited tape became Form B of the test instrument.

Plan for a pilot exposure of Form B to a large population of intermediate level students to derive item analysis data was facilitated through contacts made with the Pennsylvania Department of Education. The instrument was piloted in a large suburban Philadelphia school system using closed-circuit television. Data was amassed on a large population and, using established guidelines for accepting or rejecting items on the basis of point biserial correlations and difficulty, forty items were identified for inclusion into Form C of the Television Test of Science Processes. Results of the item analysis are cited in Chapter 4. Revision of the entire print and non-print component was effected to conform to the item analysis data. The print material was revised and new booklets printed. A major edit of the video tape was conducted to renumber all appropriate remaining questions, to include appropriate credits, and to conform to the time limits of two thirty-minute programs required for public broadcasting.

Public broadcasting over the service area of the Allegheny Educational Broadcast Council provided massive exposure and the gathering of a large data fund for a norming study. Test results from three thousand, four hundred, eighty fifth grade students from nineteen school systems of varying profiles were processed and tabulated into percentiles and T-scores and plotted into a frequency distribution. The results are cited in Chapter 4 under "Norming."

A study to determine validity was initiated. In conjunction with a large central Pennsylvania school system, data were gathered from a large population of students on a variety of variables. The students were given the TTSP, TSPT, the Science Test of the CTBS over a span of one year. This and other data were collected within safeguards of confidentiality and recorded on EDP cards. Information on fifteen variables were processed using the Pearson product-moment correlation and factor analysis programs. Within the guidelines established for a statement of criterion-related validity, it was found that the Television Test of Science Processes, Form C was moderately to highly correlated with The Science Process Test and the Science Test of the Comprehensive Test of Basic Skills. The results are cited in Chapter 4 under "Validity."

Conclusions

The data suggests content validity, appropriate readability, internal reliability coefficients approximating comparable reliability coefficients of tests of science processes, criterion related validity through moderate to high correlation with similar instruments, and a norming distribution with a moderate unimodal skew approximating a normal curve. The TTSP is a test which measures the relative achievement of those cognitive skills and abilities that we term science process. This study has presented information about the relative ordering of individuals with respect to their TTSP test performance (Glaser, 1963). A conclusion can be inferred that the successful formulation of the TTSP implies that the Test of Science Processes has been modified for use for intermediate level students and has been adapted for use through the medium of television.

What constitutes the structure of the skills and abilities of science is important to identify and quantify. In an effort to ascertain the validity of the assumptions that: (1) The Science Process Test is a statisitcally reliable and valid instrument in assessing students' ability to use the integrated processes, (2) the Test of Science Processes is a statistically reliable and valid instrument in assessing achievement in the use of science processes, and (3) the Comprehensive Tests of Basic Skills is a reliable and valid instrument to assess students' ability to investigate problems in science, additional data was amassed. Data on fifteen variables for the 215 students within the validity study were examined. These data provide information beyond the scope of this developmental study, but provided sufficiently important insights to be included as supplementary findings and is discussed in Appendix N.

Limitations of the Study

Caution is urged in the use of the listed norms. A significant difference in means exists between the norming sample and the reliability and validity sample. Also, a significant difference in means exists between the fifth grade and the sixth grade of the Lewisburg Area school population. The norming sample was exposed to the TTSP in September of their fifth grade year, while the Lewisburg students were exposed to the instrument in March of their respective grade years. These data suggest the continuous improvement in raw scores throughout the intermediate grades. Use of norming data, therefore, should be relative to appropriate time periods.

A limitation on the norming data was identified through a questionnaire cited in the study by Hill (1976). While the test exposure for the item-response-time study, item analysis pilot exposure, reliability and validity studies were under controlled conditions, the norming study exposure was under normal classroom conditions. This included the "normal" television viewing conditions. In a small number of situations, the classroom teachers expressed concern over viewing clarity and size of the television image, distortion, and vignetting (the truncating of the visuals). While all items were engineered to maximize the video signal; that is, the tapes used for the production were of broadcast quality and designed for optimum viewing transmission, some classrooms experienced less than optimal viewing conditions.

Recommendations for Further Research

A developmental study of this nature generates needs for further study both through the findings as well as the procedures. The findings suggest that it is important to define the term science processes. This definition must incorporate a clear and complete enumeration or listing of the skills and abilities employed in the sciences as well as the further refining of the skills and abilities into a possible hierarchical arrangement and developmental sequence.

In an effort to enumerate and list the skills common to practicing scientists and to obtain their judgment about the nature of science, Hogan (1969) questioned 131 scientists relative to their use of fifty strategies associated with nine identified processes. He found that the scientists held different views about the nature of science. Also, he found both significant agreement and significant disagreement in their regard for the strategies. This suggests the need to identify operating paradigms within the science community and to enumerate the common processes in order to ascertain a common definition.

A hierarchical listing of the common processes may be a necessary approach to investigate the processes of science. To list a series of unique, parallel skills, as do some philosophers, may be a faulty conceptual framework. They may, in fact, be hierarchical skills. Gagné (1970), in a discussion of the events in learning and remembering, states:

> Most scholars would agree that an initial event must be that of attending to the stimulus, although whether such attending is a process itself containing

> one, two, or perhaps three stages is a matter still actively debated. For present purposes, though, it will be convenient simply to acknowledge attending as an initial event in learning, which may be thought of as a state that can be often detected by observing what the learner is looking at or listening to. (Gagne, 1970, p. 72)

This passage alludes to the process of observing as a basic skill which underlies other processes. Such a relationship may exist among several of the processes. It is recommended that research be undertaken to fully define the processes of science.

An important factor in measuring process skills at the intermediate level is the developmental factor. Piaget (1969) suggests that cognition is an invariant developmental process with qualitatively distinct differences between the stages of thought as the child moves to more mature intellectual reasoning. It is during the intermediate grade levels that the student moves from the pre-operational to the concrete operational stage of development. These stages of development have been identified in several studies (Johnson, 1975). Tests of science processes given in these grades may tend to reflect differentiation in stages of development. It is recommended that research be conducted to identify the developmental variable and its influence on science process testing.

Questions relative to the procedure used were identified. The TTSP was designed to be used on either black and white or color television receivers. Test content was chosen so that no benefit would acrue to those students who view the test in color. Several studies suggest that there is insufficient evidence to suggest that color will improve learning from television (Chu and Schramm, 1967).

In a study to measure the relative effectiveness of two types of cueing (color and black/white), Lamberski (1975) found that black and white viewing was significantly more favorable in an immediate testing situation but found no significant difference attributable to cueing technique at a two-week delayed test analysis. It is recommended that an experimental study be undertaken to substantiate or challenge this design variable.

It became evident in the early stages of the study that the development of a test instrument involved the combined expertise from several sources. Identifiable areas of specialization were: educational testing and measurement, statistics, elementary science instruction, television production and direction, and instructional media research, to name a few. The complexity of the creation of a modern test instrument requires a structure or system to access and organize the necessary resources and personnel to produce a reliable and valid testing instrument. It is recommended that a study be undertaken to analyze and create a model for test development to optimize appropriate input and to stand as a checklist for procedure.

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APPENDIX A

LETTER OF RELEASE

Hunter College

OF THE CITY UNIVERSITY OF NEW YORK | 105 EAST 106th STREET, NEW YORK N.Y. 10029 | INSTITUTE OF HEALTH SCIENCES

360-5232

February 23, 1973

Dr. Michael Szabo
Associate Professor of Education
Pennsylvania State University
177 Chambers Building
University Park, PA 16802

Dear Dr. Szabo:

I would be both pleased and honored if you would adopt my Test of Science Processes for Pennsylvania state-wide instructional television. You certainly have my permission to use the Test of Science Processes in this venture.

If you wish to reduce the length of the test or alter it in any way, you will, of course, have to recalculate the reliability, validity, and norms.

The artwork and photographs may present you with something of a problem. Some of the original artwork for questions 13 through 96 may be available on 35mm color slides but I will have to check my files to determine if they are still usable. The rest of the artwork was only done with small glossy black and white photographs which were directly attached to the camera-ready copy and these would be unavailable since the copy is still in the possession of the printer. In other words, you may have to redo almost all of the artwork.

I hope that we can get together when you are in New York in May and if I can be of any assistance in furthering this project, please let me know.

Sincerely yours,

Robert S. Tannenbaum, Ed.D.
Director, Medical Computer
Science Program

APPENDIX B

ABRIDGED SUMMARY OF THE PROCESSES AND THEIR RESPECTIVE BEHAVIORS

Process I Observing

In order for a student to demonstrate competence in using the process of observing, he should be able to do the following:

Behaviors	Questions TSP	Questions TTSP
1. Demonstrate an operational knowledge of the physical properties of objects.	14, 19	5, 7
2. Identify and describe the results of interactions of objects and systems of objects.	17	6
3. Distinguish among various spatial relationships of the objects within a given system.	20	8

Process II Comparing

In order for a student to demonstrate competence in using the process of comparing, he should be able to do the following:

Behaviors	Questions TSP	Questions TTSP
1. Contrast on the basis of differences in their physical properties, two or more of each of the following:	7	1

a. Objects

b. Systems of objects

c. Interactions of objects and of systems of objects

d. Relative positions of objects

Process III Classifying

In order to demonstrate competence in using the process of classifying, the student should be able to do the following:

Behaviors	Questions TSP	Questions TTSP
1. Group objects or systems of objects according to a given property.	10	2
2. Select and justify an appropriate property and group objects or systems of objects according to that property.	27	9
3. Select and justify two or more appropriate simultaneous properties and group objects or systems of objects according to these properties.	28, 29	10, 11
4. Given a group of objects, identify the property or properties on which they are grouped.	11	3

Process IV Quantifying

In order for a student to demonstrate competence in using the process of quantifying, he should be able to do the following:

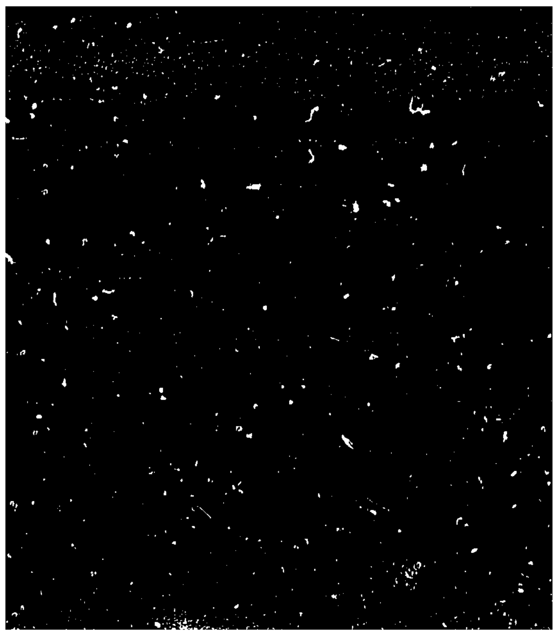
Behaviors	Questions TSP	Questions TTSP
1. Demonstrate an operational knowledge of ordinal and cardinal numbers up to one million and of negative numbers.	32	12

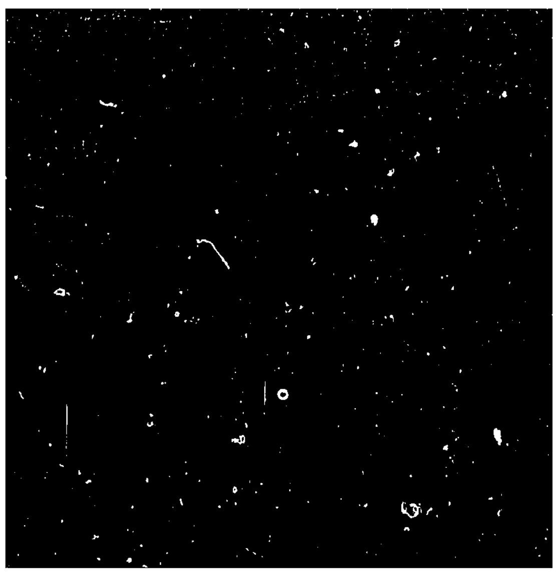
Behaviors	TSP	TTSP
2. Be able to arrange and to read data in various graphic and tabular formats.	38, 39, 40, 41	13, 14, 15, 16

Process V Measuring

In order for a student to demonstrate competence in using the process of measuring, he should be able to do the following:

Behaviors	Questions TSP	TTSP
1. Demonstrate an operational knowledge of units of measure, the function of widely accepted units, the names and appropriate sizes of the most common units such as inch, foot, centimeter, meter, pound, quart, gram, kilogram, liter, second, degree, Celsius, etc.	52, 54, 62, 66	19, 20, 24, 27
2. Demonstrate an operational knowledge of area and volume in terms of one-, two-, and three-dimensional measurements (e.g., $a=l^2$ and $a=l \times w$; $v=l^3$, $v=h \times a=h \times l^2$; and $v=h \times l \times w$).	56	21
3. Be able to measure time.	44	18
4. Be able to measure the rate of change of a property of an object or a system of objects.	59	22
5. Represent and recognize the spatial relationships among two or more objects by a scale diagram (mapping).	63, 64	25, 26
6. Recognize the appropriateness and limitations of measuring devices in a given situation.	43	17





> one, two, or perhaps three stages is a matter still actively debated. For present purposes, though, it will be convenient simply to acknowledge attending as an initial event in learning, which may be thought of as a state that can be often detected by observing what the learner is looking at or listening to. (Gagne, 1970, p. 72)

This passage alludes to the process of observing as a basic skill which underlies other processes. Such a relationship may exist among several of the processes. It is recommended that research be undertaken to fully define the processes of science.

An important factor in measuring process skills at the intermediate level is the developmental factor. Piaget (1969) suggests that cognition is an invariant developmental process with qualitatively distinct differences between the stages of thought as the child moves to more mature intellectual reasoning. It is during the intermediate grade levels that the student moves from the pre-operational to the concrete operational stage of development. These stages of development have been identified in several studies (Johnson, 1975). Tests of science processes given in these grades may tend to reflect differentiation in stages of development. It is recommended that research be conducted to identify the developmental variable and its influence on science process testing.

Questions relative to the procedure used were identified. The TTSP was designed to be used on either black and white or color television receivers. Test content was chosen so that no benefit would accrue to those students who view the test in color. Several studies suggest that there is insufficient evidence to suggest that color will improve learning from television (Chu and Schramm, 1967).

In a study to measure the relative effectiveness of two types of cueing (color and black/white), Lamberski (1975) found that black and white viewing was significantly more favorable in an immediate testing situation but found no significant difference attributable to cueing technique at a two-week delayed test analysis. It is recommended that an experimental study be undertaken to substantiate or challenge this design variable.

It became evident in the early stages of the study that the development of a test instrument involved the combined expertise from several sources. Identifiable areas of specialization were: educational testing and measurement, statistics, elementary science instruction, television production and direction, and instructional media research, to name a few. The complexity of the creation of a modern test instrument requires a structure or system to access and organize the necessary resources and personnel to produce a reliable and valid testing instrument. It is recommended that a study be undertaken to analyze and create a model for test development to optimize appropriate input and to stand as a checklist for procedure.

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In order for a student to demonstrate competence in using the process of comparing, he should be able to do the following:

Behaviors	Questions TSP	Questions TTSP
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b. Systems of objects

c. Interactions of objects and of systems of objects

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Process III Classifying

In order to demonstrate competence in using the process of classifying, the student should be able to do the following:

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2. Select and justify an appropriate property and group objects or systems of objects according to that property.	27	9
3. Select and justify two or more appropriate simultaneous properties and group objects or systems of objects according to these properties.	28, 29	10, 11
4. Given a group of objects, identify the property or properties on which they are grouped.	11	3

Process IV Quantifying

In order for a student to demonstrate competence in using the process of quantifying, he should be able to do the following:

Behaviors	Questions TSP	Questions TTSP
1. Demonstrate an operational knowledge of ordinal and cardinal numbers up to one million and of negative numbers.	32	12

		TSP	TTSP
2.	Be able to arrange and to read data in various graphic and tabular formats.	38, 39 40, 41	13, 14 15, 16

Process V Measuring

In order for a student to demonstrate competence in using the process of measuring, he should be able to do the following:

Behaviors		Questions	
		TSP	TTSP
1.	Demonstrate an operational knowledge of units of measure, the function of widely accepted units, the names and appropriate sizes of the most common units such as inch, foot, centimeter, meter, pound, quart, gram, kilogram, liter, second, degree, Celsius, etc.	52, 54 62, 66	19, 20 24, 27
2.	Demonstrate an operational knowledge of area and volume in terms of one-, two-, and three-dimensional measurements (e.g., $a=l^2$ and $a=l \times w$; $v=l^3$, $v=h \times a=h \times l^2$; and $v=h \times l \times w$).	56	21
3.	Be able to measure time.	44	18
4.	Be able to measure the rate of change of a property of an object or a system of objects.	59	22
5.	Represent and recognize the spatial relationships among two or more objects by a scale diagram (mapping).	63, 64	25, 26
6.	Recognize the appropriateness and limitations of measuring devices in a given situation.	43	17

Process VI Experimenting

In order for a student to demonstrate competence in using the process of experimenting, he should be able to do the following:

Use suitable experimental procedures in seeking solutions to problems, including possibly:

Behaviors	Questions TSP	Questions TTSP
1. Design an investigation appropriate to the problem:		
a. Select, clarify, and state in testable terms (perhaps as an answerable question) the primary variable to be investigated.	67, 71	28, 30
b. Control the variables appropriately so that logical conclusions may be drawn with regard to the primary variable.	68	29
c. Distinguish between dependent and independent variables.	72	31
2. Perform the investigation: Design, construct, or select, and successfully utilize apparatus to assist in data gathering, where appropriate.	76	32

Process VII Inferring

In order for a student to demonstrate competence in using the process of inferring, he should be able to do the following:

Behaviors	Questions TSP	Questions TTSP
1. Identify the factor most likely to have caused a given change in a system.	92	38
2. Identify and specify observations which would be needed to justify a particular generalization.	94, 96	39, 40
3. Be able to distinguish between a statement based directly on observations and one which is an inference or a generalization.		

Process VIII Predicting

In order for a student to demonstrate competence in using the process of predicting, he should be able to do the following:

Behaviors	Questions TSP	Questions TTSP
1. Be able to detect or demonstrate trends in data (presented in many different ways) and be able to use these trends to predict by extrapolation and/or interpolation.	88, 89	35, 36
2. Devise and use simple means of checking the accuracy of the predictions made.	84, 90	34, 37

APPENDIX C

SCORING KEY FOR THE
TEST OF SCIENCE PROCESSES

Instructions for Administration

The Test of Science Processes requires students to read the questions carefully and then think logically before answering. Therefore, it should be administered in a comfortable room, equipped with writing surfaces, well lit, and QUIET. In short, as with most tests, the most reliable results will be obtained under the best testing conditions.

The total actual testing time is 73 minutes or somewhat less than two regular school periods. The test must be administered during two consecutive periods for the norms and reliabilities to be applicable. If absolutely necessary, the test may be split at about the half-way point and administered at two different times. However, in this event, the user must determine his own reliabilities and norms.

The first task of the teacher is to see that each student is seated comfortably with a good writing surface, at a distance from his neighbor which is great enough to preclude collusion, and that each has a test booklet (which is to remain closed until after the instructions are completed), an answer sheet, and a piece of scrap paper (and a pencil if the test is to be machine scored). When this has been completed, the teacher should say: "I WILL NOW READ THE INSTRUCTIONS ON THE FRONT COVER OF THE TEST BOOKLET OUT LOUD WHILE YOU READ THEM TO YOURSELVES." Then the teacher should read the instructions on the cover of the test booklet aloud WITH the students following along with her.

The teacher should answer any reasonable questions which are raised during the instructions. The teacher should check to be sure that all students are filling in their answer sheets (name grids, etc.) neatly and correctly. This is especially important if the sheets are to be machine scored.

After the instructions have been completed and the teacher is satisfied that they have been understood, he should say: "NOW OPEN YOUR TEST BOOKLETS TO PAGE TWO. YOU WILL HAVE ABOUT FORTY-FIVE SECONDS FOR EACH QUESTION. YOU MAY BEGIN WORKING NOW ON QUESTION NUMBER ONE. KEEP WORKING RAPIDLY UNTIL I TELL YOU TO STOP." At this point, the teacher must begin timing the first interval of the test. These intervals are designed to keep the students moving through the test and to force them to attempt all sections of the test so that their ability to use all eight processes will be sampled.

At the end of each of the intervals listed below, the teacher should say: "YOU SHOULD NOW BE AT LEAST AT QUESTION ____ ON PAGE ____. [fill in the appropriate question and page numbers shown below.] IF YOU HAVE PASSED THIS, KEEP GOING. IF YOU HAVE NOT YET REACHED QUESTION

_____, SKIP IT NOW AND START FROM THERE. IF YOU SKIP QUESTIONS, BE SURE YOU ALSO SKIP TO THE RIGHT ANSWER SPACE. IF YOU FINISH EARLY, YOU MAY GO BACK AND WORK ON ANY QUESTIONS YOU SKIPPED."

In the table below, the intervals are given in minutes. The teacher should wait for the appropriate number of minutes to elapse, then reset his timing device, and then make the statement given above. The time required for making the statement should be included in the next interval (NOT added in between intervals).

TABLE IX TIME INTERVALS

INTERVAL	STUDENTS SHOULD BE AT	ELAPSED TIME
After 9 minutes	Question 13 on page 3	9 minutes
After 7 minutes	Question 22 on page 4	16 minutes
After 5 minutes	Question 30 on page 5	21 minutes
After 5 minutes	Question 38 on page 5	26 minutes

After 9 minutes, the teacher should say, "STOP! PUT YOUR PENCIL DOWN AND CLOSE YOUR TEST BOOKLET. YOU MAY NOW TAKE A TWO-MINUTE BREAK. YOU SHOULD STRETCH AND RELAX, BUT DO NOT TALK."

After 2 minutes	Question 50 on page 7	37 minutes
After 7 minutes	Question 59 on page 7	44 minutes
After 6 minutes	Question 67 on page 8	50 minutes
After 3 minutes	Question 71 on page 9	53 minutes
After 8 minutes	Question 79 on page 10	61 minutes
After 5 minutes	Question 84 on page 10	65 minutes
After 4 minutes	Question 90 on page 11	70 minutes

After 5 minutes, the teacher should say, "STOP! PUT YOUR PENCIL DOWN AND CLOSE YOUR TEST BOOKLET. THIS IS THE END OF THE TEST. YOU MAY NOT DO ANY MORE WORK ON IT. I AM NOW GOING TO COLLECT THE ANSWER SHEETS AND THE TEST BOOKLETS IN TWO SEPARATE PILES. PLEASE BE SURE YOU HAVE YOUR ANSWER SHEET SEPARATE FROM YOUR TEST BOOKLET."

This concludes the actual test administration. The next step is to follow the scoring instructions -- either those contained in this manual, or those which accompany the special answer sheets and scoring keys.

TABLE III

Scoring Keys

Total Test:

ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.
1	1	17	5	33	5	49	5	65	2	81	2
2	5	18	4	34	5	50	5	66	2	82	4
3	3	19	2	35	5	51	4	67	1	83	5
4	1	20	4	36	1	52	4	68	1	84	2
5	2	21	1	37	2	53	1	69	3	85	2
6	5	22	3	38	5	54	4	70	2	86	4
7	3	23	1	39	1	55	2	71	1	87	2
8	5	24	5	40	4	56	2	72	1	88	2
9	4	25	4	41	1	57	5	73	5	89	3
10	3	26	5	42	5	58	5	74	3	90	5
11	2	27	5	43	1	59	5	75	4	91	1
12	4	28	5	44	1	60	4	76	2	92	5
13	1	29	4	45	3	61	1	77	3	93	2
14	1	30	3	46	3	62	1	78	2	94	1
15	2	31	4	47	5	63	3	79	3	95	4
16	3	32	1	48	4	64	1	80	3	96	4

Process I: OBSERVING		Process II: COMPARING		Process III: CLASSIFYING		Process IV: QUANTIFYING	
ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.
13	1	3	3	1	1	30	3
14	1	7	3	2	5	31	4
15	2	22	3	4	1	32	1
16	3	23	1	5	2	33	5
17	5	24	5	6	5	34	5
18	4			9	4	35	5
19	2			10	3	36	1
20	4			11	2	37	2
21	1			25	4	38	5
				26	5	39	1
				27	5	40	4
				28	5	41	1
				29	4		

Process V: MEASURING		Process VI: EXPERIMENTING		Process VII: INFERRING		Process VIII: PREDICTING	
ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.	ITEM No.	Ans.
42	5	67	1	12	4	8	5
43	1	68	1	73	5	84	2
44	1	69	3	78	2	87	2
45	3	70	2	79	3	88	2
46	3	71	1	80	3	89	3
47	5	72	1	81	2	90	5
48	4	74	3	82	4	91	1
49	5	75	4	83	5	93	2
50	5	76	2	85	2		
51	4	77	3	86	4		
52	4			92	5		
53	1			94	1		
54	4			95	4		
55	2			96	4		
56	2						
57	5						
58	5						
59	5						
60	4						
61	1						
62	1						
63	3						
64	1						
65	2						
66	2						

Any departure from these keys (either accidental or planned) by the user, invalidates the corresponding norms, reliabilities, and validities. The user should, therefore, employ extreme care in following these keys to obtain raw scores.

APPENDIX D

CREDENTIALS OF PANEL OF JUDGES

Panel of Qualified Resource People

Dr. Dorothy E. Alfke, Professor of Science Education, The Pennsylvania State University

Dr. Alfke has been engaged in science education for the past thirty-five years since receiving a B.S., M.S., and Ph.D. from Cornell University. Her teaching experience includes five years in the New York public schools, a year teaching sixth grade in Thailand, and the remainder of her career in higher education. In addition to her teaching duties, Dr. Alfke has functioned as an evaluator for the Pennsylvania Department of Education and as a developer of science curriculum and materials. She is the author of several journal articles and serves on the writing team for the Teachers Guide and ITV Handbook for Teachers of the Science for the Seventies ITV resource.

Dr. Robert L. Shrigley, Professor of Education, The Pennsylvania State University

Dr. Shrigley received a B.S. and M.Ed. degree from Ohio State University and a D.Ed. from The Pennsylvania State University. His twenty-three years of educational experience include a year of teaching in the Ohio public schools, two years as a science advisor at Kano Teachers College in Nigeria, and ten years teaching experience at the collegiate level. In addition to his teaching duties, Dr. Shrigley currently serves as a consultant to the Curriculum Advisory Quarterly, Chicago, and to the National Association for Teachers of Biology. He is the chairman of an evaluation team for Title I programs, is the author of several articles dealing with attitudes of pre-service science teachers, and is a member of the writing team for the Teachers Guide and ITV Handbook for Teachers of the Science for the Seventies ITV resource.

Dr. Michael Szabo, Associate Professor of Science Education, The Pennsylvania State University

Dr. Szabo earned a B.S. degree from Taylor University and an M.S. and Ph.D. from Purdue University. His fourteen years in education include six years as a teacher of physics in the New Jersey and Indiana public schools and seven years at the collegiate level. Dr. Szabo has served as the assistant director of the Computer Assisted Instruction Laboratory at The Pennsylvania State University, as a member of the Title III Proposal Evaluation Team for the Pennsylvania Department of Education, and as a consultant in metric education and evaluation. He has published several articles dealing with science processes and metric education.

Dr. Paul W. Welliver, Professor of Education, The Pennsylvania State University

Dr. Welliver earned a B.A. degree from Western Maryland College and an M.Ed. and Ph.D. from The Pennsylvania State University. His 23 years of educational experience include fives years of teaching science in public schools, a year as a science lecturer at the Oak Ridge Institute of Nuclear Studies, five years as a television studio teacher, one year as a consultant in science education, one year as director of the Mississippi Instructional Television Curriculum Laboratory, two years as Director of Education for the Mississippi Authority for Educational Television, and six years teaching at the collegiate level. Dr. Welliver is the project director for the "Science for the Seventies" program and as such is responsible for the supervision and preparation of instructional lessons, teacher orientation programs and testing. Dr. Welliver is the author of numerous articles dealing with instructional development, instructional television and science education. He has also written several source books in science for teachers.

APPENDIX E

COMPUTER PRINTOUT OF SYNTACTIC DENSITY SCORE

```
**AU110205 JOB 'U1343,T=50,R=2500','GOLUB LESTER'
***PULLSKIPS
// EXEC SETTAP,TRAIN=TN,FORMS=16
***TAPE KIDR2,R
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /         / START 76127.2025
IEF374I STEP /         / STOP  76127.2025 CPU   0MIN 00.06SEC MAIN   8K LCS   OK
// EXEC RUN,PROG=WTLOG,PARM='SYNTACTICDENSITY@ @ @'
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /DATA    / START 76127.2025
IEF374I STEP /DATA    / STOP  76127.2025 CPU   0MIN 00.06SEC MAIN  12K LCS   OK
// EXEC PLIG
//SYSLIN DD UNIT=(2400,,DEFER),VOL=SER=KIDR2,LABEL=1,
//    DSN=INDEXER,DISP=(OLD,PASS),DCB=(RECFM=FB,LRECL=80,BLKSIZE=7200)
//DATA.INDEX DD DSN=&&INDEX,UNIT=SYSDA,DISP=(NEW,PASS),
//    SPACE=(CYL,(25,10),RLSE),DCB=(RECFM=FB,LRECL=32,BLKSIZE=7200)
//DATA.INPUT DD *
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /DATA    / START 76127.2025
IEF374I STEP /DATA    / STOP  76127.2025 CPU   0MIN 00.56SEC MAIN 140K LCS   OK
// EXEC PLIG
//SYSLIN DD UNIT=(2400,,DEFER),VOL=SER=KIDR2,LABEL=2,                  00000100
// DSN=SYNDEN,DISP=(OLD,PASS),DCB=(RECFM=FB,LRECL=80,BLKSIZE=7200)
//DATA.INREC DD DSN=&&INDEX,UNIT=SYSDA,DISP=(OLD,DELETE),
//  SPACE=(CYL,(25,10),RLSE),DCB=(RECFM=FB,LRECL=32,BLKSIZE=7200)
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /DATA    / START 76127.2025
IEF374I STEP /DATA    / STOP  76127.2026 CPU   0MIN 01.56SEC MAIN 140K LCS   OK
IEF375I  JOB /AU110205/ START 76127.2025
IEF376I  JOB /AU110205/ STOP  76127.2026 CPU   0MIN 02.24SEC
```

4 IS A DIFFERENT COLOR . 2 IS SMALLER . 2 IS SMALLER THAN ALL THE OTHERS AND 4 IS A DIFFERENT COLOR . 1 , 3 , 4 , AND 5 ARE THE SAME SIZE . 4 AND 2 ARE DIFFERENT FROM EACH OTHER . SAMPLE 1 FADED MORE THAN SAMPLE 2 . ALL PAPER WILL CONTINUE TO FADE FOREVER THE LONGER THEY ARE LEFT IN THE SUN . ANY PAPER LEFT IN THE SUN WILL FADE . BOTH SAMPLES FADED MORE BY DAY 5 THAN IT HAD BY DAY 2 . PAPER WILL FADE IN THE SUN , BUT CLOTH WILL NOT . THE WATER IS BOILING IN POT B . THE GAS IS ON IN POT B . THE WATER GETS HOT WHEN THE GAS IS ON . THE WATER IS NOT BOILING IN POT A . THE WATER IS BOILING IN POT B , BUT IT IS NOT BOILING IN POT A . THE HOTTER THE WATER YOU START WITH , THE FASTER IT WILL FREEZE INTO ICE CUBES . HOT WATER FREEZES INTO ICE CUBES FASTER . HOT WATER FREEZES AT HIGHER TEMPERATURES THAN COLD WATER . HOT WATER FREEZES INTO ICE CUBES FASTER BECAUSE IT TURNS ON THE REFRIGERATOR . HOT WATER MAKES STEAM - STEAM KEEPS THE REFRIGERATOR GOING . SCREWS 2 AND 3 HAVE BIG HEADS . SCREWS 2 AND 3 ARE STICKING TO THEIR MAGNETS . SOME SCREWS ARE MADE FROM A METAL WHICH IS NOT MAGNETIC . ALL THE SCREWS WITH BIG HEADS IN THIS PICTURE ARE STICKING TO THEIR MAGNETS . SCREWS 1 AND 4 ARE NOT STICKING TO THEIR MAGNETS . HANG A WEIGHT OF 75 POUNDS ON THE STRING , AND KEEP ADDING 1 - POUND WEIGHTS UNTIL IT BREAKS . HANG A 100 - POUND WEIGHT ON THE STRING AND SEE IF IT BREAKS . LET THE TWO 100 - POUND BOYS PULL ON EACH END OF A PIECE OF THE STRING AND SEE IF IT BREAKS . HANG 101 POUNDS ON THE STRING AND SEE IF IT BREAKS . DOUBLE THE STRING AND HANG 50 POUNDS FROM IT , AND SEE IF IT BREAKS . MEASURE THE BAR AT 100 C AND THEN GRAPH ALL THE NUMBERS TO CHECK YOUR ANSWERS . MEASURE THE BAR AT 120 C AND THEN MAKE A GRAPH OF ALL THE NUMBERS TO CHECK YOUR ANSWERS . PUT ALL YOUR ANSWERS ON THE CHART AND SEE IF THEY LOOK CORRECT . MEASURE THE BAR AT LEAST 5 TIMES AT OTHER TEMPERATURES AND COMPARE WHAT YOU FIND WITH YOUR ANSWERS . MEASURE THE BAR AT 40 C AND AT 100 C AND COMPARE WHAT YOU FIND WITH YOUR ANSWERS . THE BULB WAS REPLACED FOR PICTURE 2 . THE WIRES WERE TIGHTENED FOR PICTURE 2 . THE BULB WAS SCREWED-IN FOR PICTURE 2 . THE BATTERY WAS ELECTRICALLY RECHARGED FOR PICTURE 2 . ELECTRICITY IS FLOWING THROUGH THE BULB IN PICTURE 2 . FIND ONE THING THAT DOES NOT GET BIGGER WHEN IT IS HEATED . FIND ALL THE THINGS THAT DO NOT GET BIGGER WHEN THEY ARE HEATED . FIND ONE THING THAT GETS BIGGER WHEN IT IS HEATED . FIND ALL THE THINGS THAT GET BIGGER WHEN THEY ARE HEATED . FIND ALL THE THINGS THAT DO NOT CHANGE SIZE WHEN THEY ARE HEATED .

NORMAL EXECUTION OF DATA INDEX PROGRAM COMPLETED

```
OPTIONS USED - PRINT,NOMAP,NOLET,CALL,RES,NOTERM,SIZE=118784,NAME=**GO

IEW1001   IHEDDOD
IEW1001   IHEDNCA
IEW1001   IHEVSBA
IEW1001   IHEVSEA
IEW1001   IHEVSFA
IEW1001   IHEDMAA
IEW1001   IHEUPAB
IEW1001   IHEUPPB
IEW1001   IHEVSDA
IEW1001   IHEKCDA
IEW1001   IHEM91A
IEW1001   IHEM91B
IEW1001   IHEM91C
IEW1001   IHETERA
IEW1001   IHEUPAA
IEW1001   IHEUPBA
IEW1001   IHEVOBA

    TOTAL LENGTH     3858
    ENTRY ADDRESS   F0370

IEW1001     WARNING - UNRESOLVED EXTERNAL REFERENCE (NOCALL SPECIFIED)
```

```
                                                  OS/360 LOADER

OPTIONS USED - PRINT,NOMAP,NOLET,CALL,RES,NOTERM,SIZE=118784,NAME=**GO


IEW1001   IHEDDOD
IEW1001   IHEVPAA
IEW1001   IHEVPCA
IEW1001   IHEVPDA
IEW1001   IHEVPEA
IEW1001   IHEVPFA
IEW1001   IHEVPGA
IEW1001   IHEVPHA
IEW1001   IHEVPBA
IEW1001   IHEVKBA
IEW1001   IHEVKCA
IEW1001   IHEVKFA
IEW1001   IHEVKGA
IEW1001   IHEDNCA
IEW1001   IHEVSHA
IEW1001   IHEVSEA
IEW1001   IHEVSFA
IEW1001   IHEDBNA
IEW1001   IHEVQCA
IEW1001   IHEM91A
IEW1001   IHEM91B
IEW1001   IHEM91C
IEW1001   IHETERA
IEW1001   IHEUPAA
IEW1001   IHEUPBA
IEW1001   IHEUPBB
IEW1001   IHEUPAP
IEW1001   IHEVQBA

 TOTAL LENGTH    A0A8
 ENTRY ADDRESS  F6168


IEW1001    WARNING - UNRESOLVED EXTERNAL REFERENCE (NOCALL SPECIFIED)
```

NORMAL FLOW THROUGH TRANSITIONS COMPLETED

SYNTACTIC DENSITY SCORE
TABULATION SHEET

SAMPLE NO. 8

VARIABLE NUMBER	VARIABLE DESCRIPTION	VARIABLE LOADING		FREQUENCY	VLXF
	TOTAL NUMBER OF WORDS			505	
	TOTAL NUMBER OF T_UNITS			49	
1.	WORDS/T-UNIT	.95	X	10.306	9.791
2.	SUBORDINATE CLAUSES PER T-UNIT	.90	X	0.347	0.312
3.	MAIN CLAUSE WORD LENGTH (MEAN)	.20	X	8.388	1.678
4.	SUBORDINATE CLAUSE WORD LENGTH (MEAN)	.50	X	5.529	2.765
5.	NUMBER OF MODALS (WILL, SHALL, MAY, ETC.)	.65	X	8	5.188
6.	NUMBER OF BE AND HAVE FORMS	.40	X	30	11.953
7.	NUMBER OF PREPOSITIONAL PHRASES	.75	X	54	40.500
8.	NUMBER OF POSSESSIVE NOUNS AND PRONOUNS	.70	X	8	5.563
9.	NUMBER OF ADVERBS OF TIME	.60	X	10	5.938
10.	NUMBER OF GERUNDS, PARTICIPLES AND ABSOLUTES	.85	X	6	5.063

TOTAL = 88.748

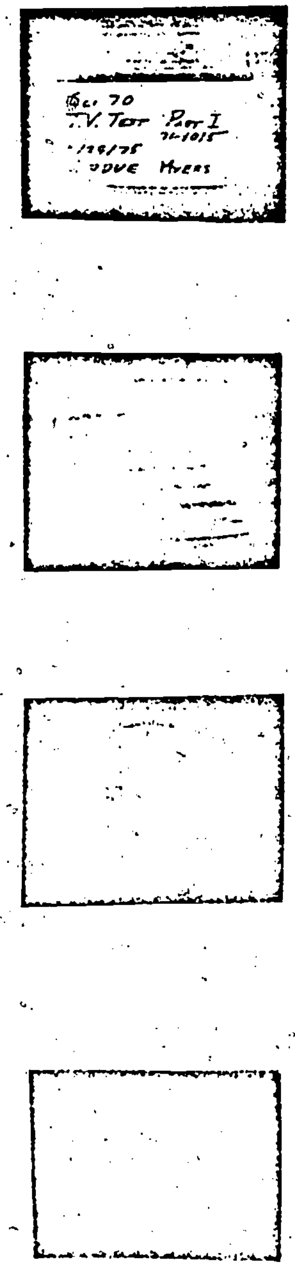
SD SCORE (TOTAL DIVIDED BY NUMBER OF T_UNITS) = 1.811

GRADE LEVEL CONVERSION TABLE

SDS:	1.0	1.5	2.0	2.5	3.0	3.5	4.0
GRADE LEVEL:	1	2	3	4	5	6	7

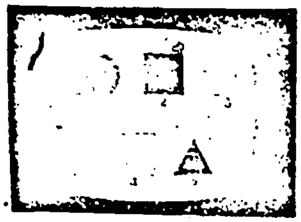
APPENDIX F

DISPLAY OF VISUALS USED IN THE TELEVISION TEST OF SCIENCE PROCESSES, FORM C



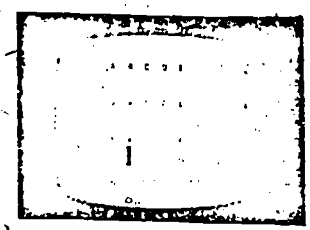
(Part of Introductory Credits of SFTS Programs)

VISUALS | EXPLANATORY INFORMATION



(Practice Question 109)

Here are 5 pieces of paper. Which piece of paper is both black and square?



(Showing How to Put Answer on Answer Sheet)

(Practice Question 110)

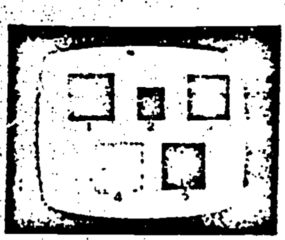
Here is a baseball on a sloping board. When the ball is released, what direction will the ball go?

(Introduction to Part One of the Test)

(Introduction to Part Two of the Test)

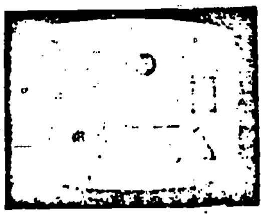
VISUALS	EXPLANATORY INFORMATION
	(SFTS Logo)
	(Introduction)
	(Narrator Introducing Test and Giving Directions for Taking the Test)
	(Showing How to Find Test Questions in Booklet Using Practice Question 110)
	(Showing How to Find Questions on Answer Sheet)

VISUALS | EXPLANATORY INFORMATION



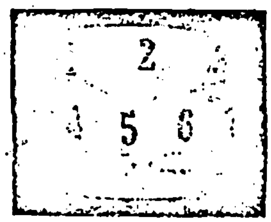
Question 1

This is a picture of 5 pieces of paper. Which statement identifies all the differences?



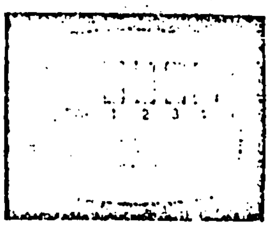
Question 2

This is a picture of 8 pieces of paper. If you group them by shape, what is the smallest number of groups you can make?



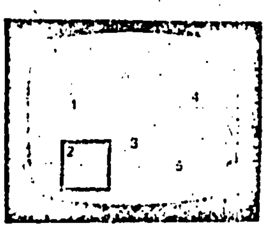
Question 3

Here are 7 toy airplanes. Airplanes 1, 2, 4, and 6 make up a special group. What does this group include?



Question 4

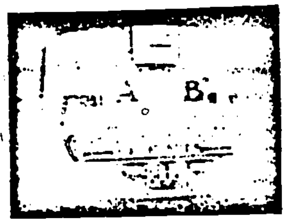
This is a picture of pieces of paper which were left in the sun for different numbers of days. Which is the only thing you can say for sure, based on what you see in the picture?



Question 5

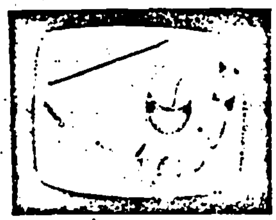
This is a picture of 5 things. Which of them has <u>volume</u>?

VISUALS | EXPLANATORY INFORMATION



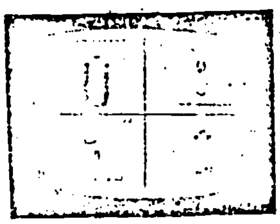
Question 6

There are two pots of water on a stove. Which choice is the best way of telling how they are different?



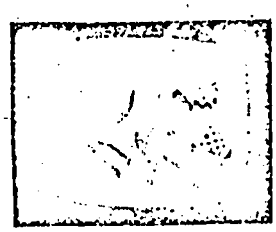
Question 7

Here are 5 objects. Which of them is NOT in the same state of matter (solid, liquid, gas) as all the others?



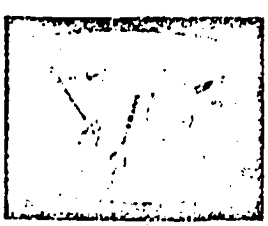
Question 8

This picture has 4 parts. Each part shows a compass, a bar magnet and a curved magnet. In which two parts are three things arranged in the same way?



Question 9

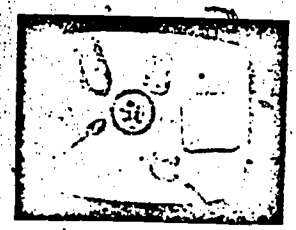
Here are 5 objects. Which objects could serve as paper weights?



Question 10

Here are 6 objects. Which objects can be used for carrying water?

VISUALS | EXPLANATORY INFORMATION

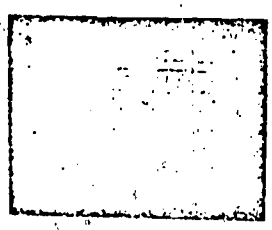


Question 11

Here are 10 marbles and 5 other objects. Which objects can be used to carry all 10 marbles at the same time?

Question 12

Which temperature reading is 25 degrees <u>lower</u> than 15° Fahrenheit?

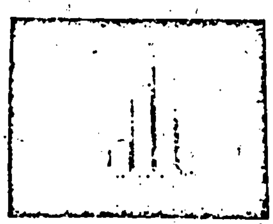


Question 13

This is a chart of information about 5 planets. Which of these planets has the longest year?

Question 14

Look at the chart again. Which 2 planets have about the same length of day?



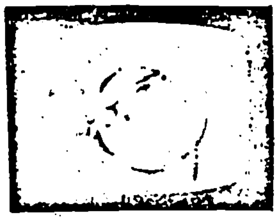
Question 15

This is a graph of the boiling temperatures of 6 different liquids. Which liquid has the <u>lowest</u> boiling temperature?

Question 16

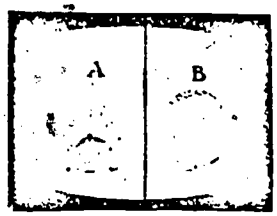
Look at the graph again. Which liquids have the same boiling temperature?

VISUALS | EXPLANATORY INFORMATION



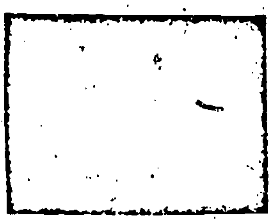
Question 17

Here is a ball. Which of these would be best for measuring the distance around this ball?



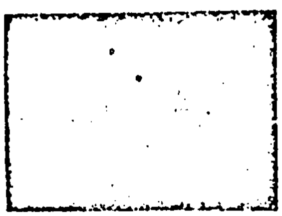
Question 18

Here are 2 clocks. In picture A it is 3:40 in the afternoon. In picture B it is 6:10 that evening. How much later was picture B taken?



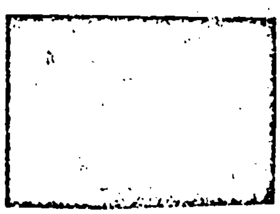
Question 19

Which unit is used in expressing area?



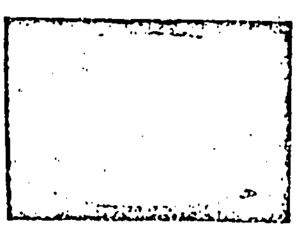
Question 20

Which unit is used in measuring weight?



Question 21

This is a picture of a box with its measurements shown on it. What is the area of the top of the box?



Question 22

This is a marble and a ruler. If the marble rolls from point A to point B in 2 seconds at a steady speed, how fast is it going?

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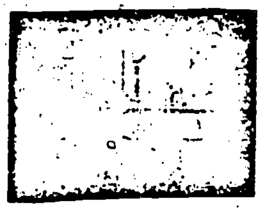
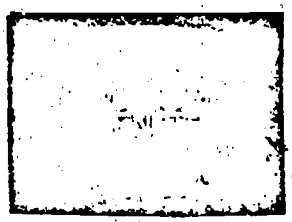


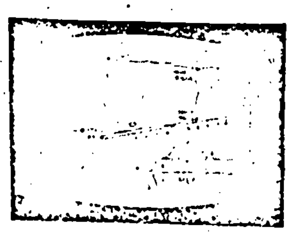
Question 23

This is a picture of a box and 5 drawings. Which is the best drawing of the box?



Question 24

Which unit is used in measuring length?

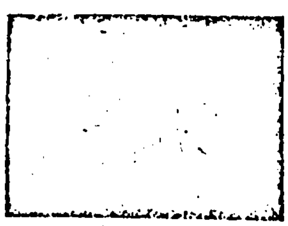


Question 25

This is a map. How far is it from North Town to Birch Falls?

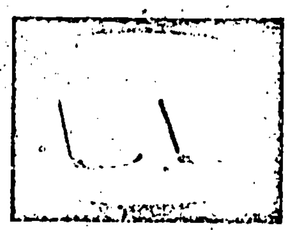
Question 26

Look at the map again. If you were using the same scale to draw another map, how far apart would you place two towns which are 5 miles from each other?



Question 27

In which pair are the units closest in size?



Question 28

These are two ice cube trays. One is filled with very hot water and one with cold water. Many people say: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER." Plan an experiment to test this. Which choice would be the best statement for helping you?

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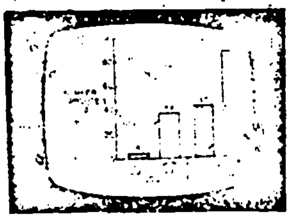
Question 29

If you want to test the statement: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER." which factor is the only one you should allow to change during the experiment?

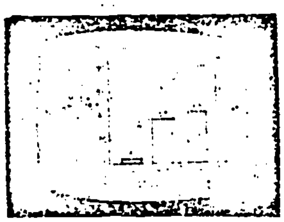


Question 30

This is a graph of the results of an experiment. 200 seeds that were 10 years old and 200 new seeds were planted in good soil and watered each day.

100 old seeds were put in a cool place
100 old seeds were put in a warm place
100 new seeds were put in a cool place
100 new seeds were put in a warm place

Five things which may affect the growth of the seeds are: water, heat, soil, age, and light. Which of these were tested?

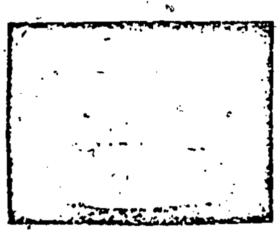


Question 31

Look at the graph again. Here are some things you can see on the graph:

1. 182 seeds sprouted
2. 200 seeds were 10 years old
3. 200 seeds were new
4. 200 seeds were kept warm
5. 200 seeds were kept cool

Which one happened because of all the others?



Question 32

Here are 5 containers which will be left out in a thunder storm. Which is the best container to use to find out how many inches of rain will fall?

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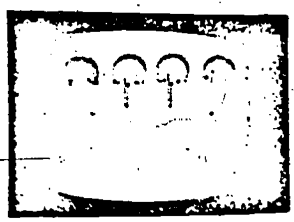
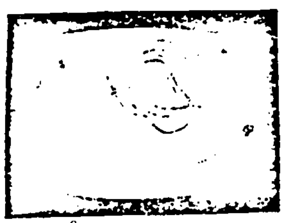


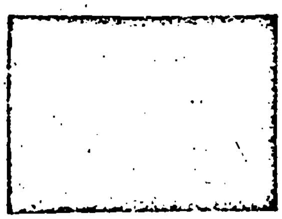
Question 33

Here are 4 screws and 4 magnets. Which statement CANNOT be made just from looking at the picture?



Question 34

Here is some string. The manufacturer claims it will hold at least 100 lbs. What is the best way to check this?



Question 35

This is a chart of the change in length of a metal bar as it is heated. What is its length at 40° C.?

Question 36

Look at the chart again. What will the length of the bar probably be at 100° C.?

Question 37

What is the best way to check the answers to the last two questions?

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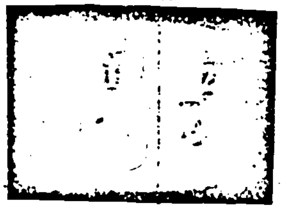
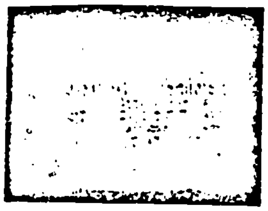


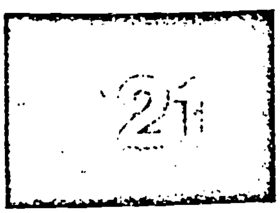
Question 38

These are 2 pictures of a battery, a bulb, a switch, and some wires. Which is the only thing you can be sure is different between the pictures?

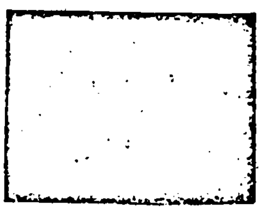


Question 39

If you want to prove that "NOT ALL THINGS GET BIGGER AS YOU HEAT THEM," what would you need to do?

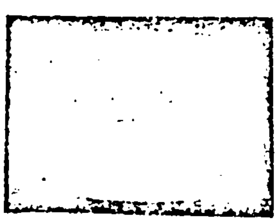


(Example of numbers used to introduce each question)



Question 40

If you want to make this statement: "THE COLDER A CITY IS, THE MORE SNOW IT HAS,' what do you need to know about some cities?



(Example of "WIPE" used on each question number)

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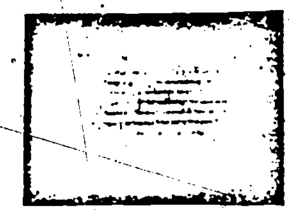

EXPLANATORY INFORMATION

(End credits to part 2 of test)

APPENDIX G

SCRIPT FOR INTRODUCTION AND SIGN-OFF

INTRODUCTION TO TEXT

PART I

VIDEO	AUDIO
SFTS Film Open Dissolve to slide of title on studio monitor. Zoom out on monitor to include Steve.	Hello. This is the "Television Test of Science Processes" Part I. Unlike many of the tests you take in school, this test will involve what you see here on the television screen. Before we begin, however, we have two practice questions that will show you how to take the test. Look at the first page of your test booklet, but do not try to answer the questions until I tell you to begin.
Punch test onto monitor. Cut to CU on camera.	Here are two practice questions numbered 109 and 110. (Point) After each question are the answer choices marked A, B, C, D, and E. (Point)
Cut to Steve and punch up answer sheet on monitor.	Now look at your answer sheet,
Cut to CU on camera.	and find answer spaces 109 and 110. Use these spaces to mark your answers to the practice questions when it is time. Be sure to mark only one answer, using a pencil to darken the space under the letter of your choice.
Cut to Steve	Before each question, the number of that question will appear on the screen like this...
Punch up 109 slide on monitor. Cut to CU on camera.	"Question 109". So you know which question we are on. Then you will see a picture on the screen like this...

VIDEO	AUDIO
Cut to test picture.	and I will ask the same question you have in your test booklet. "Here are five pieces of paper. Which piece of paper is both black and square?" Now, we will wait for one minute while you check your choices and mark your answer on the answer sheet. (Hold 1 min.)
Cut to Steve.	Okay, you should have marked your answer by now. Let's check it.
Punch up test on monitor. Cut to test picture.	Choice "A" is the only piece of paper that is both black and square. While "C" is square, it is not black.
Cut to answer sheet.	On your answer sheet you should have marked space "A" by number 109. Now here is the other practice question.
Cut to 110.	Question 110.
Cut to test picture.	"Here is a baseball on an inclined plane. When the ball is released, what direction will the ball go?" (Hold 1 min.)
Cut to Steve.	Okay. The answer is "B" -- "down the board." There are no trick questions in this test. On your answer sheet...
Cut to answer sheet.	you should have marked space "B" by question 110.
	When we begin the test, you will mark your answer to question #1 by #1 on your answer sheet. (Point)

VIDEO	AUDIO
Point to #1	
Cut to Steve.	We will now pause for 1 minute so you may ask your teacher any questions you may have about taking the test.
Cut to title slide.	(Hold 1 min.) We are now ready to beg~~in, turn to~~ question #1 in your test booklet.
Slide of title.	Close to Part I. This is the end of part one. We will continue with part two of the test at a later time. Thank you.

INTRODUCTION TO TEST

PART II

VIDEO	AUDIO
SFTS Film Open.	
Dissolve to title slide on monitor. Zoom out to Steve.	Hello. This is the "Television Test of Science Processes" Part II. At the end of part one you had answered questions 1 through 25. In part two, we will continue the test and you will answer questions 26 through 50. We will pause one minute so you may ask your teacher any questions that you may have about the test.
Cut to title.	(Hold 1 min.) We are now ready to begin, turn to question #26 in your test booklet.
Slide of title.	Close of Part II This is the end of the "Television Test of Science Processes." Thank you.

APPENDIX H

TELEVISION TEST OF SCIENCE PROCESSES
FORM A AND B

DO NOT TURN THE PAGE UNTIL THE TEACHER TELLS YOU TO DO SO

TELEVISION TEST of SCIENCE PROCESSES

INTRODUCTION

This test is different than many of the tests you take. It will involve what you see on the television screen. Choose your answers from among the choices given in this booklet. Mark your choice on the special answer sheet.

Below are two practice questions. These will help you to understand what you are to do. Wait for the television introduction before you begin.

109. Here are 5 pieces of paper. Which piece of paper is both black and square?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

110. Here is a baseball on a sloping board. When the ball is released, what direction will the ball go?

    A. up the board
    B. down the board
    C. stay where it is released
    D. will rise in the air
    E. both A and B (meaning both up and down the board)

DO NOT TURN THE PAGE UNTIL THE TEACHER TELLS YOU TO DO SO

1. Here are 5 shirts. Which shirts could be seen easily in the dark?

   A. 1 and 4
   B. 2 and 3
   C. 1, 3, and 5
   D. 2, 4, and 5
   E. 2, 3 and 5

2. This is a picture of 8 pieces of paper. Which pieces can be taken away so that they are all of one color and all of one shape?

   A. 1 and 6
   B. 2 and 8
   C. 2 and 7
   D. 1 and 3
   E. 4 and 5

3. Here are 5 objects. How are they all the <u>same</u>?

   A. They are used for eating.
   B. They are the same color.
   C. They are made of wood.
   D. They are about the same size.
   E. They are about the same shape.

4. This is a picture of 8 pieces of paper. Which pieces are black and have a triangular hole?

   A. 1, 4, and 6
   B. 1, 2, 3, 4, and 6
   C. 5 and 8
   D. 1, 4, 6, and 8
   E. 4 and 6

5. Look at the picture of the 8 pieces of paper again. Which pieces have square holes and are <u>NOT</u> black?

   A. 2, 3, 4, and 7
   B. 5 and 7
   C. 5, 7, and 8
   D. 1, 3, 5, 7, and 8
   E. 2, 3, 4, and 8

6. This is a picture of 5 pieces of paper. Which statement identifies all the differences?

   A. 4 is a different color.
   B. 2 is smaller.
   C. 2 is smaller than all the others and 4 is a different color.

D. 1, 3, 4, and 5 are the same size.
E. 4 and 2 are different from each other.

7. This is a picture of 8 pieces of paper. If you put them together by color, what is the smallest number of groups you can make?

A. 1
B. 2
C. 3
D. 4
E. 5

8. Look at the picture of 8 pieces of paper again. If you group them by shape, what is the smallest number of groups you can make?

A. 1
B. 2
C. 3
D. 4
E. 5

9. Here are 7 toy airplanes. Airplanes 1, 2, 4, and 6 make up a special group. What does this group include?

A. The planes that are modern jets
B. The planes that are not black and are modern jets
C. The planes that are black
D. The planes that are not black
E. The planes that are gray and white old-time two-wing airplanes

10. This is a picture of pieces of paper which were left in the sun for different numbers of days. Which is the only thing you can say for sure, based on what you see in the picture?

A. Sample 1 faded more than sample 2.
B. All paper will continue to fade forever the longer you leave it in the sun.
C. Any paper left in the sun will fade.
D. Both samples faded more by day 5 than it had by day 2.
E. Paper will fade in the sun, but cloth will not.

11. This is a picture of 5 things. Which of them has volume?

A. The block
B. The square
C. The circle
D. The triangle
E. The curved line

12. This is a lima bean seed. Which choice best describes only what you see?

    A. The seed is growing.
    B. Someone planted and watered the seed.
    C. The seed coat has split and a root and a stem are coming out of the seed.
    D. A root is growing down and a stem is growing up.
    E. The seed has germinated.

13. These are two pots of water on a stove. Which choice is the best way of telling how they are different?

    A. The water is boiling in picture B.
    B. The gas is on in picture B.
    C. The water gets hot when the gas is on.
    D. The water is not boiling in picture A.
    E. The water is boiling in picture B, but it is not boiling in picture A.

14. Here are 5 objects. Which of them is <u>NOT</u> in the same state of matter (solid, liquid, gas) as all the others?

    A. The pencil
    B. The water
    C. The toy whistle
    D. The ball
    E. The beads

15. This picture has 4 parts. Each part shows a compass, a bar magnet, and a curved magnet. In which two parts are three things arranged in the <u>same</u> way?

    A. 1 and 3
    B. 2 and 4
    C. 1 and 4
    D. 2 and 3
    E. 1 and 2

16. Here is a candle. Which sentence tells all that you can see in the picture and no more?

    A. Someone is holding a candle which is burning and giving off smoke.
    B. Someone has just lit a candle.
    C. A boy is holding a burning candle.
    D. Someone is about to be burned by the candle he is holding.
    E. A candle is burning and giving off light and heat.

17. Which sentence best describes these two pictures?

A. The objects are different, and they are arranged differently.
B. The objects are different, and they are placed in the same way.
C. The objects are the same, but they are placed differently.
D. The objects are the same, and they are placed in the same way.
E. Picture 2 is a mirror image of picture 1.

18. This shows two things happening. Which sentence tells a way they are the same?

A. Something is burning in both and heating something else.
B. Glass is used in both.
C. There is a solid burning in both.
D. Something is cooking in one; but in the other, something is being lit.
E. There is a liquid burning in both.

19. This is a picture of 4 items. Which items are the same?

A. 1 and 4
B. 2 and 3
C. 1, 2 and 4
D. None
E. 2 and 4

20. Here are 6 objects. Which objects are round like a ball and <u>not</u> flat?

A. 1, 2, 3, 4, and 5
B. 2, 3, and 5
C. 4 and 6
D. 2, 4, and 5
E. 1, 3, 4, and 5

21. Here are 5 objects. Which objects could serve as paper weights?

A. 1, 3, 4, and 5
B. 3 and 4
C. 1, 2, and 5
D. 2 and 5
E. 2, 4, and 5

22. Here are 6 objects. Which objects can be used for carrying water.

A. 1, 2, 3, 4, and 6
B. 1, 2, 3, and 6
C. 1, 2, 3, 4, and 5
D. 1, 2, 5, and 6
E. 1, 2, 3, and 5

23. Here are 10 marbles and 5 other objects. Which objects can be used to carry all 10 marbles at the same time?

A. 1, 3, and 5
B. 1 and 5
C. 1, 3, and 4
D. 1, 2, and 3
E. 2, 3, 4, and 5

24. Which number is five hundred sixteen thousand, three-hundred seventy-two?

A. 576,312
B. 572,316
C. 516,372
D. 372,516
E. 516,370

25. These are 4 blocks. Which choice lists the blocks <u>from shortest to tallest</u>?

A. 1, 4, 3, 2
B. 2, 4, 3, 1
C. 2, 3, 1, 4
D. 2, 3, 4, 1
E. 3, 2, 4, 1

26. Which temperature reading is 25 degrees <u>lower</u> than 15° Fahrenheit?

A. -10° Fahrenheit
B. 15° Fahrenheit
C. -25° Fahrenheit
D. 0° Fahrenheit
E. 40° Fahrenheit

27. Here are 50 straws. What fraction of all the straws is on the dark paper?

A. 1/5
B. 50/5

C. 10/25
D. 2/50
E. 1/10

28. Here are 4 glasses of colored water. Which choice lists the glasses <u>from most</u> water <u>to least</u> water?

A. 3, 1, 4, 2
B. 2, 4, 1, 3
C. 4, 3, 2, 1
D. 4, 2, 3, 1
E. 2, 4, 3, 1

29. Which of these decimals is equal to 15/100?

A. .85
B. .015
C. .20
D. 1.5
E. .15

30. If the 17th of March is Saturday, what day of the week is the 23rd of March?

A. Sunday
B. Monday
C. Tuesday
D. Thursday
E. Friday

31. This is a chart of information about 5 planets. Which of these planets has the longest year?

A. Jupiter
B. Saturn
C. Mars
D. Mercury
E. Uranus

32. Look at the chart again. Which 2 planets have about the same length of day?

A. Jupiter and Saturn
B. Mars and Jupiter
C. Mars and Uranus
D. Mercury and Uranus
E. No two

33. This is a graph of the boiling temperatures of 6 different liquids. Which liquid has the lowest boiling temperature?

A. Liquid 1
B. Liquid 2
C. Liquid 3
D. Liquid 5
E. Liquid 6

34. Look at the graph again. Which liquids have the same boiling temperature?

A. 6 and 4
B. 3 and 4
C. 1 and 5
D. 2 and 1
E. 3 and 5

35. Here is a ball. Which of these would be best for measuring the distance around this ball?

A. Tape measure
B. Meter stick
C. Yard stick
D. 1-foot ruler
E. 6-inch ruler

36. Here are 2 clocks. In picture A, it is 3:40 in the afternoon. In picture B, it is 6:10 that evening. How much later was picture B taken?

A. 2 hours and 30 minutes
B. 6 hours and 10 minutes
C. 3 hours and 40 minutes
D. 9 hours and 50 minutes
E. 9 hours and 30 minutes

37. This is a thermometer in a glass of water. What is the temperature of the water?

A. 50° Fahrenheit
B. 90° Fahrenheit
C. 20° Centigrade
D. 20° Fahrenheit
E. 9° Centigrade

38. Here is a box with its measurements shown on it. There is also a drawing of a box which has been scaled down. One measurement is left out of the scale drawing. What should it be?

A. 1 inch
B. 2 inches
C. 3 inches
D. 4 inches
E. 5 inches

39. Which unit is used in expressing area?

A. Inch
B. Cubic centimeter
C. Yard
D. Square Yard
E. Meter

40. This is a balance scale with a toothbrush on one side. If you wanted to weigh the toothbrush, what would be the best objects to balance the scales?

A. The marbles
B. The stones
C. The screws
D. The papers
E. The wires

41. Which unit is used in measuring weight?

A. Gram
B. Kilometer
C. Cubic centimeter
D. Centimeter
E. Meter

42. This is a picture of a box with its measurements shown on it. What is the area of the top of the box?

A. 20 square inches
B. 300 square inches
C. 35 cubic inches
D. 160 square inches
E. 35 square inches

43. This is a marble and a ruler. If the marble rolls from point A to point B in 2 seconds at a steady speed, how fast is it going?

A. 12 inches per 2 seconds
B. 24 inches per second
C. 2 feet per second
D. 1/2 foot per second
E. 1 foot per second

44. This is a picture of a box and 5 drawings. Which is the best drawing of the box?

A. 1
B. 2
C. 3
D. 4
E. 5

45. Which unit is used in measuring length?

A. Centimeter
B. Gram
C. Square yard
D. Acre
E. Quart

46. This is a map. How far is it from North Town to Birch Falls?

A. 9 miles
B. 18 miles
C. 4 1/2 miles
D. 27 miles
E. 6 3/4 miles

47. Look at the map again. If you were using the same scale to draw another map, how far apart would you place two towns which are 5 miles from each other?

A. 10 inches
B. 2/5 inches
C. 5 inches
D. 15 inches
E. 1 foot

48. In which pair are the units closest in size?

A. Pound and Kilometer
B. Yard and meter
C. Meter and mile
D. Gram and liter
E. Centimeter and foot

49. These are two ice cube trays. One is filled with very hot water and one with cold water. Many people say: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER." Plan an experiment to test this. Which choice would be the best statement for helping you?

A. The hotter the water you start with, the faster it will freeze into ice cubes.
B. Hot water freezes into ice cubes fast.
C. Hot water freezes at higher temperatures than cold water.
D. Hot water freezes into ice cubes faster because it turns on the refrigerator.
E. Hot water makes steam -- steam keeps the refrigerator going.

50. If you want to test the statement: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER," which factor is the only one you should allow to change during the experiment?

A. The temperature of the water you use
B. The amount of water in each tray
C. The position of the trays in the freezer
D. The refrigerator in which you put the trays
E. The kind of trays you use

51. Some things that can change during your experiment are listed below. Which one changes because of all the others?

A. The kind of trays you use
B. The refrigerator in which you put the trays
C. The time it takes for freezing
D. The temperature of the water you use
E. The amount of water in each tray

52. This is a graph of the results of an experiment. 200 seeds that were 10 years old and 200 new seeds were planted in good soil and watered each day.

100 old seeds were put in a cool place
100 old seeds were put in a warm place
100 new seeds were put in a cool place
100 new seeds were put in a warm place

Five things which may affect the growth of the seeds are: water, heat, soil, age, and light. Which of these were tested?

A. Heat and age only
B. Soil, heat and light only
C. Heat, soil, age and light only
D. Water and soil only
E. Water and age only

53. Look at the graph again. Here are some things you can see on the graph:

1. 182 seeds sprouted
2. 200 seeds were 10 years old
3. 200 seeds were new
4. 200 seeds were kept warm
5. 200 seeds were kept cool

Which one happened because of all the others?

A. 1
B. 2
C. 3
D. 4
E. 5

54. Look at the graph again. Here are five statements about this experiment:

1. More new seeds sprouted than old seeds.
2. Heat makes a difference in how many seeds sprout.
3. Age makes a difference in how many seeds sprout.
4. Water makes a difference in how many seeds sprout.
5. Water did not make a difference in how many seeds sprouted.

Which of these can you find from the graph?

A. 1 only
B. 1, 2 and 4
C. 1, 2 and 5
D. 1, 2 and 3
E. 1 and 2 only

55. Look at the graph again. Some other experiments you could do are listed on your answer sheet. Which one is <u>not</u> based on the experiment shown in the graph?

A. A study of seeds of several ages
B. A study of the effect of different soils on seeds
C. A study of the heights of plants
D. A study of the effect of different amounts of water on seeds
E. A study of the effect of different temperatures on seeds

56. Look at the graph once more. Why were 400 seeds used?

A. 400 makes 4 groups of 100 each is a round number.
B. Experiments require exactly 100 samples in each group.
C. 400 were all the seeds that were available.
D. The groups needed to be large enough so that what was found out was not wrong due to chance.
E. 400 happened to be the number taken out of the bag.

57. Here are 5 containers which will be left out in a thunder storm. Which is the best container to use to find out how many inches of rain will fall?

A. 1
B. 2
C. 3
D. 4
E. 5

58. This is a chart of wind direction at noon and midnight for one week. Which is the most general statement you can make <u>based on this chart</u>?

A. The direction of the day winds is 180° different from the direction of the night winds.
B. The direction of the wind is different at night than it is during the day.
C. There is always a wind.
D. Day winds come from the east and night winds come from the west.
E. It is warmer during the day that it is at night.

59. Here are 4 screws and 4 magnets. Which statement <u>CANNOT</u> be made just from looking at the picture?

A. Screws 2 and 3 have big heads.
B. Screws 2 and 3 are sticking to their magnets.
C. Some screws are made from a metal which is not magnetic.
D. All the screws with big heads in this picture are sticking to their magnets.
E. Screws 1 and 4 are not sticking to their magnets.

60. Here is some string. The manufacturer claims it will hold at least 100 pounds. What is the best way to check this?

A. Hang a weight of 75 pounds on the string and keep adding 1-pound weights until it breaks.

B. Hang a 100-pound weight on the string and see if it breaks.
C. Let two 100-pound boys pull on each end of a piece of the string and see if it breaks.
D. Hang 101 pounds on the string and see if it breaks.
E. Double the string and hang 50 pounds from it and see if it breaks.

61. Here is a balance scale and 6 marbles. Marbles 1, 2 and 3 all weigh the same. When marbles 1, 2, and 3 are put on one side and 4, 5, and 6 are put on the other side, they balance. Which other facts do you need to know in order to say that all the marbles weigh the same?

A. Marble 5 weighs the same as marble 2.
B. Marble 5 weighs the same as marble 2 and marble 1.
C. Marble 3 weighs the same as marble 6.
D. Marble 4 weighs the same as marble 5 and marble 6.
E. Marble 3 weighs the same as marble 5.

62. This is a barometer. From reading it, which statement about the weather can you make?

A. The barometric pressure is rising.
B. You do not have enough information to tell you what will happen.
C. The weather is changing.
D. It will rain in two days.
E. The barometric pressure is falling.

63. This is a chart of the change in length of a metal bar as it is heated. What is its length at 40° C.?

A. 101 centimeters
B. 101.5 centimeters
C. 102 centimeters
D. 102.5 centimeters
E. 103 centimeters

64. Look at the chart again. What will the length of the bar probably be at 100° C.?

A. 103.5 centimeters
B. 104 centimeters
C. 104.5 centimeters
D. 105 centimeters
E. 105.5 centimeters

65. What is the <u>best</u> way to check the answers to the last two questions?

A. Measure the bar at 100° C. and then graph all the numbers to check your answers.
B. Measure the bar at 120° C. and then make a graph of all the numbers to check your answers.
C. Put all your answers on the chart and see if they look correct.
D. Measure the bar at least 5 times at other temperatures and compare what you find with your answers.
E. Measure the bar at 40° C. and at 100° C. and compare what you find with your answers.

66. These are 2 pictures of a battery, a bulb, a switch, and some wires. Which is the only thing you can be <u>sure</u> is different between the pictures?

A. The bulb was replaced for picture 2.
B. The wires were tightened for picture 2.
C. The bulb was screwed in for picture 2.
D. The battery was electrically recharged for picture 2.
E. Electricity is flowing through the bulb in picture 2.

67. If you want to prove that "NOT ALL THINGS GET BIGGER AS YOU HEAT THEM," what would you need to do?

A. Find one thing that does not get bigger when it is heated.
B. Find all the things that do not get bigger when they are heated.
C. Find one thing that gets bigger when it is heated.
D. Find all the things that get bigger when they are heated.
E. Find all the things that do not change size when they are heated.

68. If you want to make this statement: "THE COLDER A CITY IS, THE MORE SNOW IT HAS," what do you need to know about some cities?

A. The average temperature of each city and the number of snow plows each has
B. The number of days school was closed in each city because of snow
C. The average temperature and precipitation of each city
D. The average temperature and average snowfall of each city
E. The average number times it snows in each city

APPENDIX I

TELEVISION TEST OF SCIENCE PROCESSES
FORM C

TV TEST OF SCIENCE PROCESSES

TEACHER'S TEST MANUAL

Introduction

This test is a modification of Dr. Robert Sher Tannenbaum's Test of Science Processes. It has been adapted for television presentation for the intermediate grades in an effort to assess the scientific skills and abilities that are emphasized in many of the modern science programs. Dr. Tannenbaum defines processes and the function of the test as:

"Processes" are ways of doing things. For example, scientists have to be able to look at things very carefully and tell what they see. Scientists have to be able to measure and use numbers. And, scientists have to be able to plan and understand experiments. This is a test of how well students can do some of the things scientists have to do. It is NOT a test of how many facts they know about science.

Preparation

Allow sufficient time before the scheduled TV presentation to prepare the students for the TV test. Following the introduction to Part I of the test, there will be two practice questions to show your students the test format followed immediately by the test questions. Be sure your students have the necessary materials prior to the TV presentation. They should have a pencil, a piece of scratch paper for doing any computations, an answer sheet, and a test booklet. Additional pencils and scratch paper should be accessible to the students. Do not allow the students to open the test booklet prior to the TV presentation. Do not "prime" the students in any way through your knoweldge of the test questions as this will negate the test results. To help you regulate the time and reduce the chance of a period of inactivity prior to the TV presentation, you can have students fill in the necessary student identification information on the answer sheet until the presentation begins; and complete the information after the presentation.

TV Presentation

Information regarding the time of the TV presentation of the Television Test of Science Processes will be given to you by your school district. The TV presentation will consist of two 30 minute programs given one week apart. Part I will include two practice questions and questions assessing the processes of classifying, observing, comparing, and quantifying. Part II will not repeat any of the practice questions or directions, but will include questions assessing the processes of measuring, inferring, experimenting and predicting. The programs will present all the information necessary for the questions, including the visual presentation as well as the audio presentation of the narration given in the test booklet.

Test Booklet

Inform students that they should not write in the test booklets. The test booklets contain the test questions and answer choices that are contained in the narration of the TV presentation. While there is no visual information on which to base answers, it is imperative that the students should not review any of the test questions prior to the formal presentation. This additional "cue" factor could invalidate the test results by introducing a reactive effect of interaction effect.

Answer Sheet

The answer sheet that is supplied is a machine-scored type. Instruct the students in the correct way to mark answers. The following diagram shows the correct way to fill out the name block. Answer spaces 13, 14, 19 and 20 are done incorrectly as an example of common mistakes often encountered with those not instructed in the use of this type of answer sheet.

Be sure to tell your students to choose only one answer for each question and to fill in the answer space with dark marks. If a student should change an answer, remind him to erase his first mark completely. If he breaks a pencil he is to hold up his hand and the teacher will give him a new one immediately.

There will be a single answer sheet for the two TV programs. Be sure to use a student identification number to identify the students. Collect the answer sheets and test booklets after each presentation and store in a safe place until they are requested.

PRINT LAST NAME (UP TO 9 LETTERS) AND INITIALS IN BOXES BELOW.
THEN UNDER EACH LETTER BLACKEN THE APPROPRIATE LETTER SPACE.

START			LAST NAME						FIRST INITIAL	MIDDLE INITIAL
1 D	2 O	3 E	4	5	6	7	8	9		C
A	A	A	A	A	A	A	A	A	A	A
B	B	B	B	B	B	B	B	B	B	B
C	C	C	C	C	C	C	C	C	C	C
D	D	D	D	D	D	D	D	D	D	D
E	E	E	E	E	E	E	E	E	E	E
F	F	F	F	F	F	F	F	F	F	F
G	G	G	G	G	G	G	G	G	G	G
H	H	H	H	H	H	H	H	H	H	H
I	I	I	I	I	I	I	I	I	I	I
J	J	J	J	J	J	J	J	J	J	J
K	K	K	K	K	K	K	K	K	K	K
L	L	L	L	L	L	L	L	L	L	L
M	M	M	M	M	M	M	M	M	M	M
N	N	N	N	N	N	N	N	N	N	N
O	O	O	O	O	O	O	O	O	O	O
P	P	P	P	P	P	P	P	P	P	P
Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

THE PENNSYLVANIA STATE

DATE

INSTRUCTOR

COURSE

1 A B C D E	2 A B C D E	3 A B C D E
7 A B C D E	8 A B C D E	9 A B C D E
13 A B C D E	14 A B C D E	15 A B C D E
19 A B C D E	20 A B C D E	21 A B C D E
25 A B C D E	26 A B C D E	27 A B C D E
31 A B C D E	32 A B C D E	33 A B C D E
37 A B C D E	38 A B C D E	39 A B C D E
43 A B C D E	44 A B C D E	45 A B C D E
49 A B C D E	50 A B C D E	51 A B C D E
55 A B C D E	56 A B C D E	57 A B C D E

DO NOT TURN THE PAGE UNTIL THE TEACHER TELLS YOU TO DO SO

TELEVISION TEST of SCIENCE PROCESSES

INTRODUCTION

This test is different than many of the tests you take. It will involve what you see on the television screen. Choose your answers from among the choices given in this booklet. Mark your choice on the special answer sheet.

Below are two practice questions. These will help you to understand what you are to do. Wait for the television introduction before you begin.

109. Here are 5 pieces of paper. Which piece of paper is both black and square?

   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

110. Here is a baseball on a sloping board. When the ball is released, what direction will the ball go?

   A. up the board
   B. down the board
   C. stay where it is released
   D. will rise in the air
   E. both A and B (meaning both up and down the board)

DO NOT TURN THE PAGE UNTIL THE TEACHER TELLS YOU TO DO SO

1. This is a picture of 5 pieces of paper. Which statement identifies all the differences?

A. 4 is a different color
B. 2 is smaller
C. 2 is smaller than all the others and 4 is a different color
D. 1, 3, 4, and 5 are the same size
E. 4 and 2 are different from each other

2. This is a picture of 8 pieces of paper. If you group them by shape, what is the smallest number of groups you can make?

A. 1
B. 2
C. 3
D. 4
E. 5

3. Here are 7 toy airplanes. Airplanes 1, 2, 4, and 6 make up a special group. What does this group include?

A. The planes that are modern jets
B. The planes that are not black and are modern jets
C. The planes that are black
D. The planes that are not black
E. The planes that are gray and white old-time 2-wing airplanes

4. This is a picture of pieces of paper which were left in the sun for different numbers of days. Which is the only thing you can say for sure, based on what you see in the picture?

A. Sample 1 faded more than sample 2
B. All paper will continue to fade forever the longer they are left in the sun.
C. Any paper left in the sun will fade.
D. Both samples faded more by day 5 than it had by day 2.
E. Paper will fade in the sun, but cloth will not

5. This is a picture of 5 things. Which of them has volume?

A. 1
B. 2
C. 3
D. 4
E. 5

6. There are two pots of water on a stove. Which choice is the best way of telling how they are different?

   A. The water is boiling in pot B
   B. The gas is on in pot B
   C. The water gets hot when the gas is on
   D. The water is not boiling in pot A
   E. The water is boiling in pot B, but it is not boiling in pot A

7. Here are 5 objects. Which of them is NOT in the same state of matter (solid, liquid, gas) as all the others?

   A. The pencil
   B. The water
   C. The toy whistle
   D. The ball
   E. The beads

8. This picture has 4 parts. Each part shows a compass, a bar magnet and a curved magnet. In which two parts are three things arranged in the same way?

   A. 1 and 3
   B. 2 and 4
   C. 1 and 4
   D. 2 and 3
   E. 1 and 2

9. Here are 5 objects. Which objects could serve as paper weights?

   A. 1, 3, 4 and 5
   B. 3 and 4
   C. 1, 2 and 5
   D. 2 and 5
   E. 2, 4 and 5

10. Here are 6 objects. Which objects can be used for carrying water?

   A. 1, 2, 3, 4 and 6
   B. 1, 2, 3 and 6
   C. 1, 2, 3, 4 and 5
   D. 1, 2, 5 and 6
   E. 1, 2, 3 and 5

11. Here are 10 marbles and 5 other objects. Which objects can be used to carry all 10 marbles at the same time?

   A. 1, 3 and 5
   B. 1 and 5
   C. 1, 3 and 4
   D. 1, 2 and 3
   E. 2, 3, 4 and 5

12. Which temperature reading is 25 degrees <u>lower</u> than 15° Fahrenheit?

A. - 10° Fahrenheit
B. 15° Fahrenheit
C. - 25° Fahrenheit
D. 0° Fahrenheit
E. 40° Fahrenheit

13. This is a chart of information about 5 planets. Which of these planets has the longest year?

A. Jupiter
B. Saturn
C. Mars
D. Mercury
E. Uranus

14. Look at the chart again. Which 2 planets have about the same length of day?

A. Jupiter and Saturn
B. Mars and Jupiter
C. Mars and Uranus
D. Mercury and Uranus
E. No two

15. This is a graph of the boiling temperatures of 6 different liquids. Which liquid has the <u>lowest</u> boiling temperature?

A. Liquid 1
B. Liquid 2
C. Liquid 3
D. Liquid 5
E. Liquid 6

16. Look at the graph again. Which liquids have the same boiling temperature?

A. 4 and 6
B. 3 and 4
C. 1 and 5
D. 1 and 2
E. 3 and 5

17. Here is a ball. Which of these would be best for measuring the distance around this ball?

A. Tape measure
B. Meter stick
C. Yard stick
D. 1-foot ruler
E. 6 inch ruler

18. Here are 2 clocks. In picture A, it is 3:40 in the afternoon. In picture B it is 6:10 that evening. How much later was picture B taken?

A. 2 hours and 30 minutes
B. 6 hours and 10 minutes
3. 3 hours and 40 minutes
D. 9 hours and 50 minutes
E. 9 hours and 30 minutes

19. Which unit is used in expressing area?

A. Inch
B. Cubic centimeter
C. Yard
D. Square yard
E. Meter

20. Which unit is used in measuring weight?

A. Gram
B. Kilometer
C. Cubic centimeter
D. Centimeter
E. Meter

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TELEVISION TEST
of
SCIENCE PROCESSES
Part II

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21. This is a picture of a box with its measurements shown on it. What is the area of the top of the box?

    A. 20 square inches
    B. 300 square inches
    C. 35 cubic inches
    D. 160 square inches
    E. 35 square inches

22. This is a marble and a ruler. If the marble rolls from point A to point B in 2 seconds at a steady speed, how fast is it going?

    A. 12 inches per 2 seconds
    B. 24 inches per second
    C. 2 feet per second
    D. 1/2 foot per second
    E. 1 foot per second

23. This is a picture of a box and 5 drawings. Which is the best drawing of the box?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

24. Which unit is used in measuring length?

    A. Centimeter
    B. Gram
    C. Square yard
    D. Acre
    E. Quart

25. This is a map. How far is it from North Town to Birch Falls?

    A. 9 miles
    B. 18 miles
    C. 4 1/2 miles
    D. 27 miles
    E. 6 3/4 miles

26. Look at the map again. If you were using the same scale to draw another map, how far apart would you place two towns which are 5 miles from each other?

    A. 10 inches
    B. 2/5 inches
    C. 5 inches
    D. 15 inches
    E. 1 foot

27. In which pair are the units closest in size?

A. Pound and kilometer
B. Yard and meter
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E. Centimeter and foot

28. These are two ice cube trays. One is filled with very hot water and one with cold water. Many people say: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER." Plan an experiment to test this. Which choice would be the best statement for helping you?

A. The hotter the water you start with, the faster it will freeze into ice cubes.
B. Hot water freezes into ice cubes faster.
C. Hot water freezes at higher temperatures than cold water.
D. Hot water freezes into ice cubes faster because it turns on the refrigerator.
E. Hot water makes steam - steam keeps the refrigerator going.

29. If you want to test the statement: "HOT WATER MAKES ICE CUBES QUICKER THAN COLD WATER." Which factor is the only one you should allow to change during the experiment?

A. The temperature of the water you use.
B. The amount of water in each tray.
C. The position of the trays in the freezer.
D. The refrigerator in which you put the trays.
E. The kind of trays you use.

30. This is a graph of the results of an experiment. 200 seeds that were 10 years old and 200 new seeds were planted in good soil and watered each day.
100 old seeds were put in a cool place
100 old seeds were put in a warm place
100 new seeds were put in a cool place
100 new seeds were put in a warm place
Five things which may affect the growth of the seeds are: water, heat, soil, age, and light. Which of these were tested?

A. Heat and age only
B. Soil, heat and light only
C. Heat, soil, age and light only
D. Water and soil only
E. Water and age only

31. Look at the graph again. Here are some things you can see on the graph:
    1. 182 seeds sprouted
    2. 200 seeds were 10 years old
    3. 200 seeds were new
    4. 200 seeds were kept warm
    5. 200 seeds were kept cool

    Which one happened because of all the others?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

32. Here are 5 containers which will be left out in a thunder storm. Which is the best container to use to find out how many inches of rain will fall?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

33. Here are 4 screws and 4 magnets. Which statement CANNOT be made just from looking at the picture?

    A. Screws 2 and 3 have big heads.
    B. Screws 2 and 3 are sticking to their magnets.
    C. Some screws are made from a metal which is not magnetic.
    D. All the screws with big heads in this picture are sticking to their magnets.
    E. Screws 1 and 4 are not sticking to their magnets.

34. Here is some string. The manufacturer claims it will hold at least 100 lbs. What is the best way to check this?

    A. Hang a weight of 75 pounds on the string, and keep adding 1-pound weights until it breaks.
    B. Hang a 100-pound weight on the string and see if it breaks.
    C. Let two 100-pound boys pull on each end of a piece of the string and see if it breaks.
    D. Hang 101 pounds on the string and see if it breaks.
    E. Double the string and hang 50 pounds from it, and see if it breaks.

35. This is a chart of the change in length of a metal bar as it is heated. What is its length at 40° C.?

A. 101 centimeters
B. 101.5 centimeters
C. 102 centimeters
D. 102.5 centimeters
E. 103 centimeters

36. Look at the chart again. What will the length of the bar probably be at 100°C.?

A. 103.5 centimeters
B. 104 centimeters
C. 104.5 centimeters
D. 105 centimeters
E. 105.5 centimeters

37. What is the best way to check the answers to the last two questions?

A. Measure the bar at 100° C. and then graph all the numbers to check your answers.
B. Measure the bar at 120° C. and then make a graph of all the numbers to check your answers.
C. Put all your answers on the chart and see if they look correct.
D. Measure the bar at least 5 times at other temperatures and compare what you find with your answers.
E. Measure the bar at 40° C. and at 100° C. and compare what you find with your answers.

38. These are 2 pictures of a battery, a bulb, a switch, and some wires. Which is the only thing you can be sure is different between the pictures?

A. The bulb was replaced for picture 2.
B. The wires were tightened for picture 2.
C. The bulb was screwed in for picture 2.
D. The battery was electrically recharged for picture 2.
E. Electricity is flowing through the bulb in picture 2.

39. If you want to prove that "NOT ALL THINGS GET BIGGER AS YOU HEAT THEM," What would you need to do?

A. Find one thing that does not get bigger when it is heated.
B. Find all the things that do not get bigger when they are heated.
C. Find one thing that gets bigger when it is heated.
D. Find all the things that get bigger when they are heated.
E. Find all the things that do not change size when they are heated.

40. If you want to make this statement: "THE COLDER A CITY IS, THE MORE SNOW IT HAS," What do you need to know about some cities?

A. The average temperature of each city and the number of snow plows each has.
B. The number of days school was closed in each city because of snow.
C. The average temperature and precipitation of each city.
D. The average temperature and average snowfall of each city.
E. The average number of times it snows in each city.

APPENDIX J

COMPUTER PRINTOUT OF ITEM ANALYSIS
OF PILOT TEST

ITEM ANALYSIS DATA TORRENCE - ITEM ANALYSIS

NUMBER OF STUDENTS 116 NUMBER OF TEST ITEMS 68 NUMBER OF CHOICES/ITEM 5

NO.	KEY	OMIT	A	B	C	D	E	DIFFIC. INDEX	BISER.	POINT BISER.	T-VALUE	OMIT	A	B	C	D	E
		RESPONSE TABLE < FREQUENCY:PERCENT (**-100%) >										MEAN SCORE OF THOSE RESPONDING:					
1	E	1: 1	0: 0	2: 2	0: 0	0: 0	113:97	0.974	0.434	0.258	2.854	29.0	0.0	27.0	0.0	0.0	40.5
2	A	9: 8	21:18	2: 2	14:12	56:48	14:12	0.181	0.178	0.126	1.353	45.1	42.3	37.5	39.6	38.6	41.4
3	C	1: 1	4: 3	6: 5	74:64	0: 0	31:27	0.638	0.006	0.005	0.050	29.0	34.5	40.5	40.2	0.0	39.4
4	E	1: 1	2: 2	12:10	1: 1	1: 1	99:85	0.853	-0.119	-0.081	-0.868	29.0	43.5	43.3	44.0	26.0	39.9
5	D	3: 3	0: 0	0: 0	15:13	97:84	1: 1	0.836	0.267	0.186	2.017	35.0	0.0	0.0	38.1	40.9	25.0
6	C	0: 0	9: 8	10: 9	84:72	8: 7	5: 4	0.724	0.513	0.387	4.482	0.0	37.2	31.3	42.1	33.8	30.0
7	B	1: 1	2: 2	15:13	15:13	76:66	7: 6	0.129	0.381	0.256	2.822	48.0	36.0	45.5	42.0	38.6	42.4
8	C	0: 0	1: 1	9: 8	25:22	57:49	24:21	0.216	0.330	0.240	2.639	0.0	36.0	40.6	43.8	38.8	40.0
9	B	3: 3	33:28	46:40	14:12	11: 9	9: 8	0.397	0.316	0.249	2.750	38.0	38.9	42.7	41.1	37.1	35.6
10	B	1: 1	2: 2	49:42	32:28	25:22	7: 6	0.422	0.326	0.259	2.861	47.0	33.5	42.6	41.1	35.5	38.0
11	E	3: 3	21:18	2: 2	7: 6	22:19	61:53	0.526	0.519	0.414	4.855	41.7	35.7	26.5	35.0	38.6	43.3
12	C	0: 0	13:11	6: 5	67:58	2: 2	28:24	0.578	0.235	0.186	2.025	0.0	41.1	41.3	41.5	34.0	37.0
13	A	0: 0	89:77	0: 0	3: 3	2: 2	22:19	0.767	0.490	0.369	4.123	0.0	41.8	0.0	35.7	33.0	35.1
14	D	2: 2	16:14	6: 5	14:12	70:60	8: 7	0.603	0.369	0.291	3.252	37.5	35.4	42.8	39.6	42.1	33.3
15	D	1: 1	22:19	14:12	11: 9	55:47	13:11	0.474	0.495	0.395	4.590	49.0	38.6	34.9	39.5	43.5	34.5
16	E	0: 0	8: 7	0: 0	1: 1	0: 0	107:92	0.922	0.259	0.163	1.759	0.0	36.1	0.0	33.0	0.0	40.6
17	C	0: 0	4: 3	4: 3	101:87	3: 3	4: 3	0.871	0.207	0.192	2.091	0.0	40.8	33.5	40.8	33.0	37.0
18	E	1: 1	17:15	47:41	2: 2	1: 1	48:41	0.414	-0.040	-0.032	-0.319	40.0	39.9	41.0	37.0	25.0	39.9
19	A	0: 0	103:89	6: 5	0: 0	0: 0	7: 6	0.888	0.151	0.099	1.067	0.0	40.5	40.5	0.0	0.0	35.9
20	A	2: 2	100:86	1: 1	4: 3	0: 0	9: 8	0.862	0.161	0.109	1.148	34.5	40.6	24.0	32.8	0.0	42.0
21	A	1: 1	90:78	12:10	2: 2	3: 3	8: 7	0.776	0.406	0.297	3.316	27.0	41.5	34.7	28.0	40.3	33.0
22	A	3: 3	55:47	5: 4	19:16	28:24	6: 5	0.474	0.271	0.216	2.364	37.7	42.0	42.0	36.6	38.8	41.7
23	B	1: 1	8: 7	94:81	6: 5	4: 3	3: 3	0.810	0.635	0.452	5.409	39.0	32.5	41.9	34.2	31.0	31.3
24	C	0: 0	0: 0	3: 3	110:95	0: 0	3: 3	0.948	-0.038	-0.023	-0.247	0.0	0.0	37.3	40.2	0.0	44.7
25	B	0: 0	3: 3	94:81	3: 3	2: 2	14:12	0.810	0.155	0.110	1.146	0.0	36.7	40.6	34.0	51.5	37.9
26	E	2: 2	4: 3	18:16	10: 9	7: 6	75:65	0.647	0.595	0.464	5.596	35.5	41.8	36.1	29.9	37.0	42.9
27	A	1: 1	77:66	4: 3	1: 1	19:16	14:12	0.664	0.165	0.120	1.375	40.0	40.9	36.3	36.0	39.0	39.4
28	A	1: 1	111:96	0: 0	0: 0	2: 2	2: 2	0.957	0.117	0.070	0.750	40.0	40.3	0.0	0.0	36.5	37.5
29	A	5: 4	55:47	14:12	3: 3	35:30	4: 3	0.474	0.230	0.190	2.066	34.0	41.8	40.6	41.3	38.3	40.0
30	A	1: 1	104:90	8: 7	1: 1	1: 1	1: 1	0.897	0.300	0.195	2.124	27.0	40.7	37.9	39.0	24.0	35.0
31	A	11: 9	65:56	12:10	1: 1	9: 8	18:16	0.560	0.408	0.325	3.664	35.0	42.5	38.5	27.0	40.7	36.3
32	E	11: 9	3: 3	2: 2	3: 3	2: 2	95:82	0.819	0.534	0.378	4.353	35.9	26.7	35.5	37.7	26.0	41.6
33	B	0: 0	2: 2	107:92	6: 5	1: 1	0: 0	0.922	0.337	0.211	2.309	0.0	34.0	40.7	35.8	27.0	0.0
34	E	1: 1	1: 1	1: 1	0: 0	1: 1	112:97	0.966	0.300	0.178	1.933	27.0	39.0	39.0	0.0	35.0	40.5
35	E	1: 1	1: 1	0: 0	2: 2	1: 1	111:96	0.957	0.377	0.226	2.472	24.0	39.0	0.0	36.0	24.0	40.6
36	E	3: 3	1: 1	2: 2	27:23	3: 3	80:69	0.690	0.367	0.282	3.136	36.3	34.0	35.5	37.6	32.7	41.7
37	C	24:21	2: 2	16:14	64:55	5: 4	5: 4	0.552	0.322	0.257	2.834	38.0	35.5	39.1	42.0	34.2	38.8
38	A	9: 8	25:22	29:25	22:19	20:17	11: 9	0.216	0.221	0.160	1.736	36.1	42.6	40.8	36.8	42.8	38.7
39	B	2: 2	6: 5	68:59	16:14	18:16	6: 5	0.586	0.448	0.354	4.047	34.0	28.7	42.6	36.0	41.9	33.3
40	E	1: 1	33:28	10: 9	37:32	7: 6	28:24	0.241	-0.074	-0.056	-0.599	24.0	42.8	39.5	40.4	33.7	39.4
41	E	1: 1	2: 2	2: 2	2: 2	3: 3	106:91	0.914	0.533	0.338	3.835	24.0	30.5	29.5	29.0	37.7	41.0
42	D	3: 3	29:25	4: 3	33:28	24:21	23:20	0.207	0.544	0.421	4.962	40.0	39.6	39.0	39.5	46.8	36.9
43	A	3: 3	58:50	7: 5	7: 6	10: 9	31:27	0.500	0.520	0.415	4.867	31.0	43.5	37.0	33.9	36.1	38.5
44	E	2: 2	7: 6	43:37	10: 9	8: 7	46:40	0.397	0.517	0.407	4.764	31.0	42.0	38.1	33.2	38.0	44.2
45	E	2: 2	1: 1	8: 7	19:16	3: 3	83:72	0.716	0.446	0.370	3.816	31.5	43.0	40.9	34.6	32.3	41.9
46	C	5: 4	4: 3	2: 2	55:47	19:16	31:27	0.474	0.318	0.253	2.795	33.2	35.8	39.0	42.3	41.6	37.5
47	E	4: 3	5: 4	3: 3	28:24	19:16	57:49	0.491	0.452	0.361	4.131	28.8	33.0	36.0	38.4	39.2	43.1
48	D	1: 1	7: 6	23:20	3: 3	76:66	6: 5	0.655	0.768	0.597	7.944	24.0	34.7	31.2	29.7	43.6	38.0
49	E	3: 3	12:10	3: 3	17:15	8: 7	73:63	0.629	0.409	0.321	3.615	30.7	40.8	33.0	37.4	33.7	42.2
50	E	1: 1	4: 3	3: 3	16:14	7: 6	85:73	0.733	0.343	0.258	2.946	24.0	42.0	32.3	34.1	34.7	41.4
51	C	4: 3	5: 4	28:24	68:59	7: 6	4: 3	0.586	0.249	0.197	2.151	33.8	40.4	39.2	41.5	35.7	39.3
52	E	3: 3	2: 2	5: 4	25:22	15:13	66:57	0.569	0.611	0.485	5.927	35.3	28.5	32.8	36.6	36.6	43.6
53	E	5: 4	3: 3	16:14	13:11	15:13	64:55	0.552	0.670	0.517	6.450	34.4	29.3	33.9	36.5	38.7	43.9

54	A	3; 3	12;10	43;37	24;21	18;16	16;14	0.103	0.277	0.180	1.956	32.3	44.4	42.5	41.0	37.0	34.8
55	C	4; 3	10; 9	16;14	46;40	27;23	13;11	0.397	0.311	0.245	2.698	33.0	37.4	39.8	42.6	39.3	38.5
56	B	2; 2	5; 4	41;35	9; 8	22;19	37;32	0.353	0.208	0.162	1.754	26.0	37.4	42.0	32.4	39.8	41.6
57	C	3; 3	9; 8	5; 4	60;52	0; 0	39;34	0.517	0.312	0.249	2.739	32.3	34.1	35.2	42.1	0.0	39.9
58	D	2; 2	10; 9	40;34	9; 8	51;44	4; 3	0.440	0.110	0.088	0.941	20.5	36.4	41.8	35.6	41.0	39.3
59	C	1; 1	20;17	11; 9	57;49	13;11	14;12	0.491	0.507	0.404	4.721	24.0	36.1	39.0	43.5	31.6	41.0
60	D	1; 1	6; 5	4; 3	3; 3	68;59	34;29	0.586	0.473	0.374	4.310	24.0	36.3	36.5	28.3	42.7	37.9
61	B	3; 3	10; 9	42;36	30;26	20;17	11; 9	0.362	0.153	0.120	1.290	32.0	38.0	41.5	40.6	39.3	40.5
62	D	2; 2	3; 3	7; 6	4; 3	34;29	66;57	0.293	0.043	0.033	0.349	36.5	35.3	36.1	35.3	40.6	41.1
63	D	2; 2	8; 7	6; 5	7; 6	80;69	13;11	0.690	0.818	0.628	8.610	26.5	32.8	31.5	31.9	43.5	34.9
64	C	3; 3	13;11	41;35	36;31	7; 6	16;14	0.310	0.550	0.422	4.967	29.7	35.4	40.8	45.2	35.3	35.6
65	A	2; 2	55;47	14;12	10; 9	5; 4	30;26	0.474	0.443	0.354	4.035	26.0	43.2	40.3	34.3	37.0	38.2
66	A	4; 3	64;55	8; 7	9; 8	19;16	12;10	0.552	0.565	0.449	5.368	36.8	43.4	31.0	38.0	36.	38.1
67	E	1; 1	34;29	10; 9	9; 8	16;14	46;40	0.397	0.390	0.307	3.448	24.0	39.7	37.5	36.8	37.3	43.2
68	B	3; 3	9; 8	68;59	26;22	7; 6	3; 3	0.586	0.565	0.447	5.339	30.0	31.8	43.2	39.0	34.9	31.7

ADDITIONAL TEST INFORMATION

NUMBER OF STUDENTS 116 NUMBER OF TEST ITEMS 68 NUMBER OF CHOICES/ITEM 5

TEST MEAN = 40.22 STANDARD DEVIATION = 7.92 TEST RANGE = 38

KUDER-RICHARDSON 20 RELIABILITY = 0.807 STANDARD ERROR OF MEASUREMENT = 3.48 STANDARD ERROR OF CORRELATION = 0.093

THE MEAN DIFFICULTY OF THE ITEMS ON THIS TEST = 0.591 ESTIMATED INTERITEM CORRELATION = 0.122

THE AVERAGE ITEM-TOTAL SCORE CORRELATION FOR THE QUESTIONS IN THIS TEST = 0.350

DISTRIBUTION OF THE TEST ITEMS
IN TERMS OF THE PERCENTAGE OF STUDENTS PASSING THEM

PERCENT PASSING	NUMBER OF ITEMS
0 - 19	3
20 - 39	8
40 - 59	27
60 - 79	13
80 -100	17

DISTRIBUTION OF THE TEST ITEMS
IN TERMS OF ITEM-TOTAL SCORE CORRELATIONS

CORRELATIONS	NUMBER OF ITEMS
NEGATIVE - .10	6
.11 - .30	20
.31 - .50	26
.51 - .70	14
.71 - .90	2
.91 -1.00	0

CHOICES	% KEYED	% CHOSEN	AVE. DIFF.
A	0.235	0.193	0.504
B	0.147	0.157	0.538
C	0.191	0.194	0.562
D	0.132	0.159	0.532
E	0.294	0.284	0.670

% KEYED= FREQUENCY OF A GIVEN KEY DIVIDED BY THE NUMBER OF ITEMS.
% CHOSEN= FREQUENCY OF A GIVEN RESPONSE DIVIDED BY THE TOTAL NUMBER OF RESPONSES TO ALL ITEMS (EXCL. OMITS).
AVE. DIFF.= TOTAL OF ALL DIFFICULTY VALUES FOR ITEMS WITH A GIVEN KEY DIVIDED BY THE NUMBER OF SUCH ITEMS.

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F128-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LIST
          DEFAULT OPTION(S) USED -  SIZE=(135168,20576)
****LOAD1      DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET
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APPENDIX K

COMPUTER PRINTOUT OF ITEM ANALYSIS, TABLE OF EQUIVALENTS, AND FREQUENCY DISTRIBUTION OF THE NORMING SAMPLE

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HASP-II***HASP-II***HASP-II***..........START JOB  166....AA225967......TORRENCE DAVID P..............***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB  166....AA225967......TORRENCE DAVID P..............***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB  166....AA225967......TORRENCE DAVID P..............***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB  166....AA225967......TORRENCE DAVID P..............***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB  166....AA225967......TORRENCE DAVID P..............***HASP-II***HASP-II***  OR=AA
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TIME: 11:11:29 DATE: 05/11/76              H A S P   S Y S T E M   L O G

**AA225967 JOB 'U3169,T=59,P=2500','TORRENCE DAVID P'
***FULLSKIPS
// EXEC SPITAF,TRAIN=TN,FORMS=16
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /        / START 76130.1311
IEF374I STEP /        / STOP  76130.1311 CPU    0MIN 00.07SEC MAIN   8K LCS    0K
// EXEC FGLG
//OBJECT.INPUT DD *
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /OBJECT  / START 76130.1311
IEF374I STEP /OBJECT  / STOP  76130.1311 CPU    0MIN 00.11SEC MAIN 134K LCS    0K
//DATA.INPUT DD *
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /DATA    / START 76130.1311
IEF374I STEP /DATA    / STOP  76130.1311 CPU    0MIN 01.82SEC MAIN  84K LCS    0K
IEF375I  JOB /AA225967/ START 76130.1311
IEF376I  JOB /AA225967/ STOP  76130.1311 CPU    0MIN 02.20SEC
```

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ITEM ANALYSIS DATA TORRENCE 07/14/76

NUMBER OF STUDENTS 3480 NUMBER OF TEST ITEMS 40 NUMBER OF CHOICES/ITEM 5

NO.	KEY	OMIT	A	B	C	D	E	DIFFIC. INDEX	DISCR.	POINT BISER.	T-VALUE	OMIT	A	B	C	D	E
			RESPONSE TABLE < FREQUENCY;PERCENT (***=100%) >									MEAN SCORE OF THOSE RESPONDING:					
1	C	72; 2	450;13	693;20	***;32	762;22	394;11	0.319	0.492	0.379	24.134	9.0	14.8	13.5	18.9	15.4	15.7
2	C	72; 2	825;24	***;44	687;19	271; 8	124; 4	0.186	0.216	0.153	9.149	8.8	15.7	16.1	17.7	14.6	14.2
3	D	70; 2	794;23	465;13	280; 8	584;17	***;37	0.168	0.308	0.215	12.993	10.2	15.2	16.2	14.0	18.5	15.9
4	D	70; 2	528;15	933;27	774;22	701;20	474;14	0.201	0.345	0.248	15.116	9.7	15.2	15.6	15.9	18.6	14.6
5	A	104; 3	881;25	555;16	793;23	477;14	670;19	0.253	0.271	0.202	12.164	12.6	17.8	16.0	15.3	15.2	15.3
6	E	55; 2	***;24	393;11	99; 3	56; 2	***;58	0.536	0.562	0.440	29.568	7.5	14.2	11.7	14.6	13.4	18.2
7	B	72; 2	423;12	***;46	404;12	433;12	532;15	0.464	0.356	0.284	17.370	9.2	14.0	17.6	15.0	14.5	15.4
8	C	73; 2	506;15	***;39	384;11	391;11	807;23	0.110	0.052	0.034	2.013	9.5	14.5	17.4	16.5	14.3	15.6
9	E	71; 2	351;10	521;15	377;11	373;11	***;51	0.513	0.502	0.400	25.776	9.7	14.6	13.5	13.6	14.2	18.0
10	E	61; 2	271; 8	485;14	682;20	229; 7	***;50	0.503	0.389	0.310	19.232	9.2	13.4	13.5	15.5	14.6	17.6
11	D	92; 3	383;11	179; 5	300; 9	***;68	167; 5	0.670	0.500	0.386	24.570	10.4	12.5	12.8	13.9	17.4	13.9
12	A	125; 4	***;34	231; 7	406;12	***;33	401;12	0.330	0.344	0.267	16.326	13.7	18.0	13.2	14.9	15.6	15.1
13	E	71; 2	483;14	206; 8	169; 5	736;21	***;50	0.499	0.380	0.303	18.756	9.5	15.5	14.6	12.7	14.3	17.6
14	A	77; 2	***;73	214; 6	201; 6	197; 6	239; 7	0.733	0.510	0.383	24.370	9.0	17.2	12.1	12.6	12.6	14.1
15	D	52; 1	66; 2	14; 0	107; 4	***;85	255; 7	0.847	0.524	0.361	22.316	7.4	12.6	10.9	13.4	16.8	10.8
16	A	54; 2	***;91	29; 1	70; 2	119; 3	47; 1	0.909	0.575	0.367	23.282	7.1	16.6	12.1	10.5	9.5	10.9
17	A	56; 2	***;86	119; 3	64; 2	91; 3	144; 4	0.864	0.540	0.365	23.141	7.3	16.7	12.5	10.0	11.5	11.5
18	A	69; 2	***;58	251; 7	908;26	120; 3	113; 3	0.580	0.355	0.281	17.277	8.4	17.2	12.7	15.2	11.1	14.4
19	D	73; 2	199; 6	757;22	716;21	***;35	527;15	0.347	0.462	0.360	22.748	8.4	14.6	14.5	15.0	19.6	14.8
20	A	66; 2	***;52	611;18	294; 8	314; 9	389;11	0.519	0.530	0.429	28.303	8.1	18.2	14.7	13.2	11.1	13.4
21	B	149; 4	***;47	211; 6	684;20	89; 3	697;20	0.061	0.079	0.048	2.342	12.4	15.3	17.0	16.6	15.8	17.3
22	E	120; 3	***;31	808;23	259; 7	380;11	827;24	0.238	0.431	0.318	19.760	12.6	15.5	14.6	14.5	15.6	19.0
23	A	74; 2	***;22	305; 9	553;16	***;31	466;13	0.290	0.357	0.271	16.532	11.0	18.2	14.1	14.4	15.6	15.8
24	A	77; 2	***;38	238; 7	***;45	181; 5	85; 2	0.384	0.405	0.319	19.925	10.7	18.1	13.0	15.0	16.1	11.5
25	C	66; 2	***;45	391;11	***;31	168; 5	210; 6	0.309	0.518	0.397	25.330	10.0	14.4	16.4	19.1	11.0	14.8
26	A	79; 2	***;38	398;11	932;27	303; 9	463;13	0.375	0.450	0.353	22.234	10.5	18.4	15.5	15.5	13.4	13.1
27	B	87; 2	265; 8	***;35	532;15	547;16	840;24	0.347	0.369	0.287	17.563	11.0	15.1	18.1	14.3	15.8	14.8
28	A	78; 2	956;27	583;17	***;29	319; 9	540;16	0.275	0.223	0.168	10.352	10.9	17.4	14.8	16.1	15.1	15.6
29	A	79; 2	***;40	771;22	572;16	305; 9	348;10	0.403	0.339	0.260	16.402	10.8	17.7	14.8	15.6	14.1	15.0
30	A	102; 3	722;21	570;16	***;31	654;19	354;10	0.207	0.329	0.238	14.443	11.7	18.4	15.2	16.2	14.6	15.2
31	A	105; 3	***;32	411;12	579;17	824;24	442;13	0.322	0.392	0.302	18.703	12.7	19.3	14.8	15.0	15.2	14.5
32	C	61; 2	***;40	73; 2	***;41	340;10	198; 6	0.407	0.321	0.254	15.397	10.0	15.2	12.8	17.6	14.0	15.6
33	C	65; 2	420;12	405;12	***;35	507;15	866;25	0.347	0.460	0.358	22.596	10.1	14.0	14.4	18.6	15.6	14.6
34	B	64; 2	***;33	***;45	243; 7	231; 7	230; 7	0.451	0.162	0.129	7.682	10.2	16.6	16.7	12.9	14.6	13.8
35	B	95; 3	589;17	***;39	564;16	413;12	459;13	0.391	0.527	0.415	26.921	12.0	15.0	18.7	14.1	13.9	13.9
36	C	102; 3	567;16	455;13	634;18	952;27	770;22	0.182	0.248	0.176	10.514	12.1	14.0	14.2	17.9	17.0	16.0
37	E	102; 3	793;23	398;11	576;17	670;19	941;27	0.270	0.397	0.299	18.468	11.5	15.3	14.3	14.4	16.0	18.6
38	E	77; 2	492;14	473;14	548;16	400;11	***;43	0.424	0.482	0.383	24.421	10.7	14.3	13.5	15.0	14.5	18.3
39	A	73; 2	***;33	514;15	386;11	325; 9	***;29	0.331	0.300	0.232	14.079	10.7	17.7	15.2	13.5	14.8	16.0
40	D	104; 3	578;17	332;10	608;20	***;37	494;14	0.169	0.470	0.368	23.356	11.4	13.7	13.4	15.4	18.5	15.3

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ADDITIONAL TEST INFORMATION

NUMBER OF STUDENTS 3980 NUMBER OF TEST ITEMS 40 NUMBER OF CHOICES/ITEM 5

TEST MEAN = 15.96 STANDARD DEVIATION = 5.35 TEST RANGE = 38

KUDER-RICHARDSON 20 RELIABILITY = 0.736 STANDARD ERROR OF MEASUREMENT = 2.75 STANDARD ERROR OF CORRELATION = 0.017

THE MEAN DIFFICULTY OF THE ITEMS ON THIS TEST = 0.399 ESTIMATED INTERITEM CORRELATION = 0.150

THE AVERAGE ITEM-TOTAL SCORE CORRELATION FOR THE QUESTIONS IN THIS TEST = 0.387

DISTRIBUTION OF THE TEST ITEMS IN TERMS OF THE PERCENTAGE OF STUDENTS PASSING THEM

PERCENT PASSING	NUMBER OF ITEMS
0 - 19	5
20 - 39	18
40 - 59	12
60 - 79	2
80 -100	3

DISTRIBUTION OF THE TEST ITEMS IN TERMS OF ITEM-TOTAL SCORE CORRELATIONS

CORRELATIONS	NUMBER OF ITEMS
NEGATIVE - .10	2
.11 - .30	7
.31 - .50	23
.51 - .70	8
.71 - .90	0
.91 -1.00	0

CHOICES	% KEYED	% CHOSEN	AVE. DIFF.
A	0.375	0.291	0.452
B	0.125	0.163	0.343
C	0.175	0.172	0.266
D	0.150	0.169	0.435
E	0.175	0.183	0.427

% KEYED= FREQUENCY OF A GIVEN KEY DIVIDED BY THE NUMBER OF ITEMS.
% CHOSEN= FREQUENCY OF A GIVEN RESPONSE DIVIDED BY THE TOTAL NUMBER OF RESPONSES TO ALL ITEMS (EXCL. OMITS).
AVE. DIFF.= TOTAL OF ALL DIFFICULTY VALUES FOR ITEMS WITH A GIVEN KEY DIVIDED BY THE NUMBER OF SUCH ITEMS.

F128-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LIST
DEFAULT OPTION(S) USED - SIZE=(135168,20576)
****LOAD1 DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET

TORRENCE TOTAL GROUP

NUMBER OF STUDENTS [illegible] NUMBER OF TEST ITEMS 40

TABLE OF EQUIVALENTS AND FREQUENCY DISTRIBUTION

EACH SCORE REPRESENTS 0.23 PER CENT OF THE DISTRIBUTION

*** WARNING SCORE FREQUENCIES EXCEED MAXIMUM PLOTTING LIMITS.
*** THE KURTOTIC PROPERTY OF THIS GRAPH IS THEREBY DISTORTED

SCORE	T-SCORE	CENTILE	FREQ	DISTRIBUTION (EACH X = 5 SCORE/S)
1	22	1	3	IX
2	24	1	4	IX
3	26	1	9	IX
4	29	1	13	IXX
5	30	1	21	IXXXX
6	31	2	40	IXXXXXXXX
7	33	3	68	IXXXXXXXXXXXXX
8	35	5	76	IXXXXXXXXXXXXXXX
9	37	8	116	IXXXXXXXXXXXXXXXXXXXXXXX
10	39	12	143	IXXXXXXXXXXXXXXXXXXXXXXXXXXXX
11	41	16	186	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
12	43	23	244	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
13	44	30	249	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
14	46	37	292	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
15	48	45	274	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
16	50	53	252	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
17	52	60	253	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
18	54	67	223	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
19	56	73	188	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
20	58	78	172	IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
21	59	83	132	IXXXXXXXXXXXXXXXXXXXXXXXXXX
22	61	87	110	IXXXXXXXXXXXXXXXXXXXXXX
23	63	89	73	IXXXXXXXXXXXXXXX
24	65	91	75	IXXXXXXXXXXXXXXX
25	67	93	61	IXXXXXXXXXXXX
26	69	95	49	IXXXXXXXXXX
27	71	96	47	IXXXXXXXXX
28	73	97	33	IXXXXXXX
29	74	98	22	IXXXX
30	76	99	14	IXX
31	78	99	10	IXX
32	80	99	4	IX
33	82	99	3	IX
34	84	99	1	IX
35	86	99	2	IX
36	87	99	2	IX
37	89	99	0	I
38	91	99	1	IX

TOTAL 3482

ADDITIONAL TEST INFORMATION

TEST MEAN = 15.96

TEST VARIANCE = 28.56

TEST STANDARD DEVIATION = 5.35

TEST RANGE = 18

STANDARD ERROR OF MEASUREMENT = 3.12

STANDARD ERROR OF TEST MEAN = 0.09

KUDER-RICHARDSON 21 RELIABILITY = 0.682

SKEWNESS = 0.392

KURTOSIS = 3.211

**** ANALYSIS COMPLETED ****

```
UNT: U3168               MAXIMUM TIME (SEC):      50  EST CPU (SEC):          3
: 05/17/76 IDENT:        ACTUAL TIME, INCLUDING 2.0 SEC SYSTEM TIME:   10 @ $.10/SEC = $  1.00
: TORRENCE DAVID R       LINES PRINTED:           91  CARDS PUNCHED:      0 @ $.17/100 = $  0.00
INATION: AA              MAXIMUM RECORDS:       2500  TOTAL RECORDS:     91 @ $.06/100 = $  0.06
1.8 PA-R-2.TAN 370/168   CARDS READ:            3620       ***** TOTAL COST = $  1.06  JOB NAME PA 2 25067
```

```
F128-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LIST
          DEFAULT OPTION(S) USED -  SIZE=(135168,24576)
****LOAD1      DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET
```

APPENDIX L

LEWISBURG - 5TH

NUMBER OF STUDENTS 204 NUMBER OF TEST ITEMS 40

TABLE OF EQUIVALENTS AND FREQUENCY DISTRIBUTION

EACH SCORE REPRESENTS 0.49 PER CENT OF THE DISTRIBUTION

SCORE	T-SCORE	CENTILE	FREQ.	DISTRIBUTION (EACH X = 1 SCORE/S)
5	28	1	1	IX
6	29	1	0	I
7	31	1	2	IXX
8	33	1	0	I
9	34	2	6	IXXXXXX
10	36	6	7	IXXXXXXX
11	37	9	7	IXXXXXXX
12	39	14	13	IXXXXXXXXXXXXX
13	41	19	7	IXXXXXXX
14	42	24	14	IXXXXXXXXXXXXXX
15	44	30	11	IXXXXXXXXXXX
16	45	36	12	IXXXXXXXXXXXX
17	47	42	12	IXXXXXXXXXXXX
18	49	47	9	IXXXXXXXXX
19	50	52	14	IXXXXXXXXXXXXXX
20	52	59	11	IXXXXXXXXXXX
21	53	63	9	IXXXXXXXXX
22	55	69	14	IXXXXXXXXXXXXXX
23	56	75	8	IXXXXXXXX
24	58	78	6	IXXXXXX
25	60	81	6	IXXXXXX
26	61	84	5	IXXXXX
27	63	87	8	IXXXXXXXX
28	64	90	4	IXXXX
29	66	92	4	IXXXX
30	68	93	2	IXX
31	69	94	3	IXXX
32	71	97	8	IXXXXXXXX
33	72	99	1	IX

TOTAL 204

ADDITIONAL TEST INFORMATION

TEST MEAN = 10.94

TEST VARIANCE = 38.45

TEST STANDARD DEVIATION = 6.20

TEST RANGE = 29

STANDARD ERROR OF MEASUREMENT = 3.00

STANDARD ERROR OF TEST MEAN = 0.44

KUDER-RICHARDSON 21 RELIABILITY = 0.766

SKEWNESS = 0.311

KURTOSIS = 2.380

ITEM ANALYSIS DATA TORRENCE - LEWISBURG 5

NUMBER OF STUDENTS, 204 NUMBER OF TEST ITEMS 40. NUMBER OF CHOICES/ITEM 5

NO.	KEY	OMIT	A	B	C	D	E	DIFFIC. INDEX	BISER.	POINT BISER.	T-VALUE	OMIT	A	B	C	D	E
		RESPONSE TABLE < FREQUENCY;PERCENT (**=100%) >										MEAN SCORE OF THOSE RESPONDING:					
1	C	0: 0	29;14	14; 7	107;52	35;17	19; 9	0.525	0.685	0.546	9.267	0.0	16.7	15.9	21.2	14.9	18.3
2	C	1: 0	55;27	84;41	48;24	11; 5	5; 2	0.235	0.276	0.203	2.947	16.0	18.4	19.8	22.2	20.2	15.4
3	D	1: 0	29;14	39;19	12; 6	53;26	71;35	0.260	0.360	0.270	3.978	13.0	15.7	19.2	21.3	22.8	19.7
4	D	2: 1	30;15	61;30	49;24	55;27	7; 3	0.270	0.364	0.274	4.045	11.5	18.4	19.6	18.9	22.7	15.7
5	A	2: 1	94;46	27;13	36;18	12; 6	33;16	0.461	0.518	0.429	6.746	12.5	22.0	19.6	16.6	16.3	17.0
6	E	0: 0	51;26	15; 7	6; 3	0; 0	130;64	0.637	0.569	0.445	7.061	0.0	15.9	15.2	20.5	0.0	22.0
7	B	2: 1	19; 9	112;55	19; 9	21;10	31;15	0.549	0.407	0.324	4.872	15.5	17.5	21.0	16.2	17.7	18.6
8	C	1: 0	16; 8	95;47	25;12	25;12	42;21	0.123	0.028	0.019	0.266	13.0	15.0	22.2	20.2	18.0	17.6
9	E	0: 0	10; 5	19; 9	9; 4	14; 7	152;75	0.745	0.477	0.356	5.407	0.0	18.7	16.1	14.7	14.9	21.2
10	E	1: 0	6; 3	20;10	24;12	6; 3	147;72	0.721	0.414	0.313	4.691	17.0	14.7	18.3	18.7	18.7	21.1
11	D	0: 0	12; 6	5; 2	12; 6	168;82	7; 3	0.824	0.494	0.348	5.268	0.0	13.8	16.0	18.7	20.9	10.7
12	A	5: 2	88;43	10; 5	26;13	57;28	18; 9	0.431	0.375	0.298	4.438	16.6	22.1	17.2	17.2	19.2	17.6
13	E	0: 0	22;11	13; 6	4; 2	43;21	122;60	0.598	0.357	0.282	4.181	0.0	19.9	20.6	13.8	16.0	21.4
14	A	0: 0	173;85	10; 5	6; 3	5; 2	10; 5	0.848	0.420	0.289	4.286	0.0	20.7	13.2	13.5	13.4	20.2
15	D	0: 0	2; 1	0; 0	4; 2	189;93	9; 4	0.926	0.447	0.279	4.122	0.0	20.0	0.0	13.5	20.4	12.2
16	A	2: 1	196;96	1; 0	1; 0	3; 1	1; 0	0.961	0.494	0.294	4.377	11.5	20.3	5.0	13.0	10.3	13.0
17	A	0: 0	195;96	3; 1	3; 1	1; 0	2; 1	0.956	0.483	0.289	4.291	0.0	20.3	12.0	11.0	13.0	10.0
18	A	1: 0	124;61	8; 4	65;32	2; 1	4; 2	0.608	0.320	0.252	3.703	25.0	21.2	13.6	18.4	21.0	15.0
19	D	0: 0	11; 5	40;20	26;13	109;53	18; 9	0.534	0.405	0.323	4.850	0.0	16.5	18.9	17.2	21.8	16.3
20	A	1: 0	148;73	23;11	11; 5	11; 5	10; 5	0.725	0.595	0.448	7.130	15.0	21.6	16.3	14.7	13.1	15.9
21	B	0: 0	77;38	27;13	42;21	8; 4	50;25	0.132	0.762	0.513	8.405	0.0	17.4	28.2	17.8	22.1	20.6
22	E	0: 0	62;30	38;19	15; 7	17; 8	72;35	0.353	0.649	0.506	8.338	0.0	18.5	16.9	15.9	16.8	24.2
23	A	0: 0	70;34	7; 3	18; 9	91;45	18; 9	0.343	0.530	0.411	6.417	0.0	[illegible]	14.3	14.8	19.1	17.2
24	A	0: 0	122;60	9; 4	59;29	10; 5	4; 2	0.598	0.403	0.318	4.773	0.0	21.5	15.1	17.9	17.7	14.5
25	C	0: 0	121;59	16; 8	56;27	4; 2	7; 3	0.275	0.751	0.566	9.765	0.0	17.4	21.7	25.7	11.0	17.6
26	A	0: 0	64;31	11; 5	72;35	25;12	32;16	0.314	0.600	0.461	7.392	0.0	24.2	16.5	18.7	16.4	17.9
27	B	2: 1	10; 5	100;49	26;13	31;16	33;16	0.490	0.506	0.404	6.276	15.5	16.7	22.5	17.7	18.5	16.3
28	A	1: 0	59;29	34;17	57;28	29;14	24;12	0.289	0.242	0.184	2.655	16.0	21.7	19.3	19.2	19.2	18.9
29	A	0: 0	102;50	32;16	38;19	12; 6	20;10	0.500	0.290	0.231	3.381	0.0	21.4	16.4	20.9	17.9	17.1
30	A	1: 0	55;27	32;16	69;34	28;14	19; 9	0.270	0.625	0.470	7.572	12.0	24.8	17.1	18.6	18.6	17.4
31	A	2: 1	93;46	16; 8	31;15	41;20	21;10	0.456	0.698	0.556	9.506	15.5	23.7	17.4	16.8	16.1	17.0
32	C	0: 0	46;23	9; 4	122;60	18; 9	9; 4	0.598	0.397	0.314	4.695	0.0	18.6	13.4	21.5	17.1	16.2
33	C	0: 0	13; 6	25;12	99;49	26;13	41;20	0.485	0.553	0.441	6.932	0.0	15.8	17.6	22.8	18.3	16.6
34	B	0: 0	72;35	95;47	14; 7	9; 4	14; 7	0.466	0.187	0.149	2.138	0.0	20.0	20.9	16.6	19.6	16.1
35	B	4: 2	28;14	108;53	26;13	20;10	18; 9	0.529	0.663	0.528	8.839	16.5	17.0	23.0	17.5	14.8	15.2
36	C	3: 1	15; 7	14; 7	55;27	84;41	33;16	0.270	0.283	0.213	3.097	14.3	16.5	16.0	22.1	20.0	19.5
37	E	1: 0	45;22	11; 5	36;18	50;25	61;30	0.299	0.413	0.315	4.724	25.0	18.1	17.3	16.9	20.4	21.9
38	E	0: 0	39;19	18; 9	31;15	16; 8	100;49	0.490	0.528	0.421	6.595	0.0	18.1	15.6	17.0	16.1	22.6
39	A	0: 0	73;36	39;19	19; 9	24;12	49;24	0.358	0.453	0.353	5.369	0.0	22.9	18.7	14.4	16.3	20.2
40	D	1: 0	30;15	10; 5	58;28	88;43	17; 8	0.431	0.556	0.441	6.990	12.0	17.4	14.9	18.1	23.1	17.1

ADDITIONAL TEST INFORMATION

NUMBER OF STUDENTS 204 | NUMBER OF TEST ITEMS 40 | NUMBER OF CHOICES/ITEM 5

TEST MEAN = 19.80 | STANDARD DEVIATION = 6.35 | TEST RANGE = 30

KUDER-RICHARDSON 20 RELIABILITY = 0.819 STANDARD ERROR OF MEASUREMENT = 2.70 STANDARD ERROR OF CORRELATION = 0.070

THE MEAN DIFFICULTY OF THE ITEMS ON THIS TEST = 0.497 ESTIMATED INTERITEM CORRELATION = 0.216

THE AVERAGE ITEM-TOTAL SCORE CORRELATION FOR THE QUESTIONS IN THIS TEST = 0.465

DISTRIBUTION OF THE TEST ITEMS
IN TERMS OF THE PERCENTAGE OF STUDENTS PASSING THEM

PERCENT PASSING	NUMBER OF ITEMS
0 - 19	2
20 - 39	12
40 - 59	13
60 - 79	8
80 -100	5

DISTRIBUTION OF THE TEST ITEMS
IN TERMS OF ITEM-TOTAL SCORE CORRELATIONS

CORRELATIONS	NUMBER OF ITEMS
NEGATIVE - .10	1
.11 - .30	5
.31 - .50	19
.51 - .70	13
.71 - .90	2
.91 -1.00	0

CHOICES	% KEYED	% CHOSEN	AVE. DIFF.
A	0.375	0.307	0.541
B	0.125	0.153	0.433
C	0.175	0.176	0.359
D	0.150	0.178	0.541
E	0.175	0.181	0.549

% KEYED= FREQUENCY OF A GIVEN KEY DIVIDED BY THE NUMBER OF ITEMS.
% CHOSEN= FREQUENCY OF A GIVEN RESPONSE DIVIDED BY THE TOTAL NUMBER OF RESPONSES TO ALL ITEMS (EXCL. OMITS).
AVE. DIFF.= TOTAL OF ALL DIFFICULTY VALUES FOR ITEMS WITH A GIVEN KEY DIVIDED BY THE NUMBER OF SUCH ITEMS.

APPENDIX M

COMPUTER PRINTOUT OF THE STATISTICAL PACKAGE PROGRAM OF THE VALIDITY SAMPLE ON FIFTEEN SELECTED VARIABLES

```
*************************
*                       *
* BEGIN   STPAC   OUTPUT *
*                       *
*************************
```

```
THERE ARE     8192 WORDS OF CORE AVAILABLE FOR ARRAY STORAGE DURING THIS RUN.

THERE ARE     12288 BYTES OF CORE AVAILABLE FOR I/O BUFFERS

     1.00   EXECUTE DPMCR
     2.00   VARIABLES 15
     3.00   VARIABLE NAMES 1='TTSP TOTAL',2='TTSP CLASS SUB',3='TSPT TOTAL',4='TSPT TIME'
     4.00   VARIABLE NAMES 5='SFTAA VERBAL',6='SFT  /NON-VERB',7='SFTAA TOTAL'
     5.00   VARIABLE NAMES 8='CTBS RDG VOCAB',9='CTBS RDG COMP',10='CTBS LANG TOTAL'
     6.00   VARIABLE NAMES 11='CTBS MATH',12='CTBS SCIENCE',13='CTBS SOC STUD',14='RPT CARD'
     7.00   VARIABLE NAMES 15='OTIS IQ'
     8.00   FORMAT (7X,15F3.0)
     9.00   MISSING DATA 0.0
    10.00   BEGIN DATA
            0010530020170241000060081501097066365500442002
            0020070029340111351151236337126165636837190003
            003         0240261000940098507500481000482523003
            0040470040220271071088085575041527476493571003
            0050600040250211081121060160269558950461500 4
            006         022028117111510601624605447002558002
            0070520010260201201117121557602560552560371900 3
            00809559030310273115111111055767955358966057100 3
            009056      015028124105117557520533076563158003
            0100560030320161271211206016796415897106830004

                          TOTAL OF  215 DATA CARDS

    11.00   END DATA
```

```
****************************
*                          *
* BEGIN      NCR    OUTPUT *
*                          *
****************************
```

THIS PROGRAM WAS LAST REVISED ON MAY 9, 1972

THE WRITE-UP WAS LAST REVISED ON MAY 9, 1972

THE RAW DATA FOR THIS PROBLEM CONTAINS 15 VARIABLES

THE FORMAT OF THE DATA IS - (3X,15F3.0)

MISSING DATA IS DESIGNATED BY A VALUE OF 0.0

THE FIRST CASE WAS READ AND INTERPRETED AS FOLLOWS:

VARIABLE		VALUE	VARIABLE		VALUE	VARIABLE		VALUE	VARIABLE		VALUE
TTSP TOT	1	53.0000	TTSP CLA	2	2.0000	TSPT TOT	3	17.0000	TSPT TIM	4	24.0000
SFTAA VR	5	106.0000	SFTAA NO	6	60.0000	SFTAA TO	7	81.0000	CTBS RDG	8	541.0000
CTBS RDG	9	497.0000	CTBS LAN	10	466.0000	CTBS MAT	11	365.0000	CTBS SCI	12	504.0000
CTBS SOC	13	442.0000	RPT CARD	14	2.0000	OTIS IQ	15	0.0			

TOTAL NUMBER OF DATA CARDS PROCESSED: 215 NUMBER OF OBSERVATIONS: 215

170

VARIABLE	MEAN	STD. DEV.	NOBS	VARIABLE	MEAN	STD. DEV.	NOBS	VARIABLE	MEAN	STD. DEV.	NOBS
1 [illegible] TOT	47.4632	9.73871	190	6 SPTAN NO	103.3302	15.79743	215	11 CTBS MAT	457.1442	79.20972	215
2 [illegible] CLA	13.0726	3.24421	179	7 SPTAN TO	103.4605	15.27741	215	12 CTBS SCI	521.0043	85.27550	215
3 [illegible] TOT	29.2778	7.11790	198	8 CTBS RDG	501.0279	85.51832	215	13 CTBS SOC	520.5860	96.20240	215
4 [illegible] FIN	26.4423	6.32375	190	9 CTBS RDG	516.0698	102.49390	215	14 RPT CARD	2.5130	0.66107	209
5 SPTAN VE	102.9395	15.22728	215	10 CTBS LAN	489.4977	82.21825	215	15 OTIS IQ	127.4078	14.44272	46

PAIR X		Y	R	MEAN X	MEAN Y	ST.DEV.X	ST.DEV.Y	N
TTSP CLA	2-	1 TTSP TOT	0.172	3.074	47.765	1.268	9.506	179
TSPT TOT	3-	1 TTSP TOT	0.658	20.273	47.635	7.167	9.878	177
TSPT TOT	3-	2 TTSP CLA	0.099	20.377	3.092	7.086	3.156	167
TSPT TIM	4-	1 TTSP TOT	-0.063	26.615	47.680	6.110	9.964	178
TSPT TIM	4-	2 TTSP CLA	-0.225	26.593	3.085	6.161	3.780	164
TSPT TIM	4-	3 TSPT TOT	0.052	26.870	20.415	5.963	7.209	171
SETAA VE	5-	1 TTSP TOT	0.552	102.916	47.463	14.998	9.739	190
SETAA VE	5-	2 TTSP CLA	0.036	103.078	3.073	15.306	3.248	179
SETAA VE	5-	3 TSPT TOT	0.770	103.095	20.278	15.361	7.178	198
SETAA VE	5-	4 TSPT TIM	-0.121	103.115	26.742	15.256	6.024	194
SETAA RD	6-	1 TTSP TOT	0.676	103.774	47.463	16.088	9.739	190
SETAA RD	6-	2 TTSP CLA	0.189	104.419	3.073	15.997	3.248	179
SETAA RD	6-	3 TSPT TOT	0.720	103.566	20.278	16.134	7.178	198
SETAA RD	6-	4 TSPT TIM	-0.043	103.691	26.742	16.239	6.024	194
SETAA RD	6-	5 SETAA VE	0.660	103.330	102.940	15.797	15.227	215
SETAA TO	7-	1 TTSP TOT	0.641	103.621	47.463	15.235	9.739	190
SETAA TO	7-	2 TTSP CLA	0.139	104.017	3.073	15.249	3.248	179
SETAA TO	7-	3 TSPT TOT	0.813	103.662	20.278	15.534	7.178	198
SETAA TO	7-	4 TSPT TIM	-0.091	103.930	26.742	15.580	6.024	194
SETAA TO	7-	5 SETAA VE	0.929	103.460	102.940	15.277	15.227	215
SETAA TO	7-	6 SETAA RD	0.898	103.460	103.330	15.277	15.797	215
CTBS RDG	8-	1 TTSP TOT	0.620	499.590	47.463	82.528	9.739	190
CTBS RDG	8-	2 TTSP CLA	0.003	500.274	3.073	82.285	3.248	179
CTBS RDG	8-	3 TSPT TOT	0.770	501.313	20.278	87.140	7.178	198
CTBS RDG	8-	4 TSPT TIM	-0.139	502.012	26.742	86.922	6.024	194
CTBS RDG	8-	5 SETAA VE	0.860	501.029	102.940	85.518	15.227	215
CTBS RDG	8-	6 SETAA RD	0.651	501.028	103.330	85.510	15.797	215
CTBS RDG	8-	7 SETAA TO	0.902	501.028	103.460	85.510	15.277	215
CTBS RDG	9-	1 TTSP TOT	0.611	515.470	47.463	97.920	9.739	190
CTBS RDG	9-	2 TTSP CLA	0.038	519.017	3.073	96.126	3.248	179
CTBS RDG	9-	3 TSPT TOT	0.709	512.722	20.278	103.489	7.178	198
CTBS RDG	9-	4 TSPT TIM	-0.110	510.433	26.742	103.414	6.024	194
CTBS RDG	9-	5 SETAA VE	0.901	516.070	102.940	102.494	15.227	215
CTBS RDG	9-	6 SETAA RD	0.643	516.070	103.330	102.494	15.797	215
CTBS RDG	9-	7 SETAA TO	0.900	516.070	103.460	102.494	15.277	215
CTBS RDG	9-	8 CTBS RDG	0.850	516.070	501.029	102.494	85.518	215
CTBS LAN	10-	1 TTSP TOT	0.685	490.595	47.463	81.229	9.739	190
CTBS LAN	10-	2 TTSP CLA	0.031	491.771	3.073	82.431	3.248	179
CTBS LAN	10-	3 TSPT TOT	0.737	492.172	20.278	83.045	7.178	198
CTBS LAN	10-	4 TSPT TIM	-0.127	492.959	26.742	83.416	6.024	194
CTBS LAN	10-	5 SETAA VE	0.770	489.498	102.940	82.218	15.227	215
CTBS LAN	10-	6 SETAA RD	0.665	489.498	103.330	82.218	15.797	215
CTBS LAN	10-	7 SETAA TO	0.796	489.498	103.460	82.218	15.277	215
CTBS LAN	10-	8 CTBS RDG	0.922	489.498	501.029	82.218	85.518	215
CTBS LAN	10-	9 CTBS RDG	0.802	489.498	516.070	82.218	102.494	215
CTBS MAT	11-	1 TTSP TOT	0.653	457.542	47.463	79.791	9.739	190
CTBS MAT	11-	2 TTSP CLA	0.068	459.726	3.073	80.105	3.248	179
CTBS MAT	11-	3 TSPT TOT	0.770	459.040	20.278	81.253	7.178	198
CTBS MAT	11-	4 TSPT TIM	-0.201	460.832	26.742	80.805	6.024	194
CTBS MAT	11-	5 SETAA VE	0.710	457.199	102.940	79.209	15.227	215

PAIR X	Y	R	MEAN X	MEAN Y	ST.DEV.X	ST.DEV.Y	N
CTBS MAT 11-	6 SETAA MO	0.793	457.144	103.330	79.209	15.797	215
CTBS MAT 11-	7 SETAA TO	0.812	457.144	103.460	79.209	15.277	215
CTBS MAT 11-	8 CTBS RDG	0.754	457.144	501.028	79.209	85.518	215
CTBS MAT 11-	9 CTBS RDG	0.746	457.144	516.070	79.209	102.818	215
CTBS MAT 11-	10 CTBS LAN	0.792	457.144	488.898	79.209	82.218	215
CTBS SCI 12-	1 TTSP TOT	0.660	521.960	47.463	86.250	9.719	190
CTBS SCI 12-	2 TTSP CLA	0.073	521.207	3.573	85.503	1.248	179
CTBS SCI 12-	3 TSPT TOT	0.761	521.246	20.278	87.638	7.178	190
CTBS SCI 12-	4 TSPT TIM	-0.081	522.613	26.702	87.519	6.624	198
CTBS SCI 12-	5 SETAA VS	0.755	521.088	102.980	85.206	15.227	215
CTBS SCI 12-	6 SETAA MO	0.723	521.088	103.330	85.206	15.797	215
CTBS SCI 12-	7 SETAA TO	0.813	521.088	103.460	85.206	15.277	215
CTBS SCI 12-	8 CTBS RDG	0.775	521.088	501.028	85.206	85.518	215
CTBS SCI 12-	9 CTBS RDG	0.783	521.088	516.070	85.206	102.898	215
CTBS SCI 12-	10 CTBS LAN	0.737	521.088	488.898	85.206	82.218	215
CTBS SCI 12-	11 CTBS MAT	0.764	521.088	457.144	85.206	79.209	215
CTBS SOC 13-	1 TTSP TOT	0.638	513.297	47.463	96.587	9.739	190
CTBS SOC 13-	2 TTSP CLA	0.071	521.514	3.573	96.229	1.248	179
CTBS SOC 13-	3 TSPT TOT	0.783	520.192	20.278	98.105	7.178	198
CTBS SOC 13-	4 TSPT TIM	-0.040	522.165	26.702	97.733	6.624	198
CTBS SOC 13-	5 SETAA VS	0.791	520.586	102.980	96.282	15.227	215
CTBS SOC 13-	6 SETAA MO	0.770	520.586	103.330	96.282	15.797	215
CTBS SOC 13-	7 SETAA TO	0.831	520.586	103.460	96.282	15.277	215
CTBS SOC 13-	8 CTBS RDG	0.812	520.586	501.028	96.282	85.518	215
CTBS SOC 13-	9 CTBS RDG	[illegible]	520.586	516.070	96.282	102.888	215
CTBS SOC 13-	10 CTBS LAN	0.791	520.586	488.898	96.282	82.218	215
CTBS SOC 13-	11 CTBS MAT	0.769	520.586	457.144	96.282	79.209	215
CTBS SOC 13-	12 CTBS SCI	0.773	520.586	521.088	96.282	85.206	215
PPT CARD 14-	1 TTSP TOT	0.570	2.516	47.598	0.868	9.769	188
PPT CARD 14-	2 TTSP CLA	0.148	2.546	3.080	0.871	1.298	178
PPT CARD 14-	3 TSPT TOT	0.690	2.519	20.528	0.866	7.076	193
PPT CARD 14-	4 TSPT TIM	0.006	2.595	26.746	0.866	6.066	189
PPT CARD 14-	5 SETAA VS	0.593	2.512	103.450	0.861	15.218	209
PPT CARD 14-	6 SETAA MO	0.659	2.512	103.560	0.861	15.937	209
PPT CARD 14-	7 SETAA TO	0.669	2.512	103.688	0.861	15.347	209
PPT CARD 14-	8 CTBS RDG	0.686	2.512	502.188	0.861	85.676	209
PPT CARD 14-	9 CTBS RDG	0.612	2.512	518.038	0.861	101.598	209
PPT CARD 14-	10 CTBS LAN	0.682	2.512	491.622	0.861	81.659	209
PPT CARD 14-	11 CTBS MAT	0.691	2.512	459.230	0.861	79.193	209
PPT CARD 14-	12 CTBS SCI	[illegible]	2.512	521.751	0.861	84.246	209
PPT CARD 14-	13 CTBS SOC	0.639	2.512	521.751	0.861	94.977	209
OTIS IQ 15-	1 TTSP TOT	0.527	107.369	47.608	16.493	9.363	46
OTIS IQ 15-	2 TTSP CLA	0.369	107.636	3.250	16.746	1.018	44
OTIS IQ 15-	3 TSPT TOT	0.627	107.205	21.205	16.881	6.910	44
OTIS IQ 15-	4 TSPT TIM	-0.095	107.112	29.837	17.092	5.149	43
OTIS IQ 15-	5 SETAA VS	0.772	107.109	101.435	16.493	14.599	46
OTIS IQ 15-	6 SETAA MO	0.778	107.108	106.152	16.493	16.691	46
OTIS IQ 15-	7 SETAA TO	[illegible]	107.108	124.957	16.493	14.681	46
OTIS IQ 15-	8 CTBS RDG	0.736	107.109	509.126	16.493	79.451	46
OTIS IQ 15-	9 CTBS RDG	0.715	107.198	517.696	16.493	94.517	46

PATH X	Y	R	MEAN X	MEAN Y	ST.DEV.X	ST.DEV.Y	N
OTIS IQ	15- 10 CTBS LAN	0.772	107.348	501.109	16.493	75.954	46
OTIS IQ	15- 11 CTBS MAT	0.055	107.348	461.957	16.493	81.300	46
OTIS IQ	15- 12 CTBS SCI	0.749	107.348	524.840	16.493	75.295	46
OTIS IQ	15- 13 CTBS SOC	0.741	107.348	524.848	16.493	91.384	46
OTIS IQ	15- 14 RPT CARD	0.547	107.200	2.578	16.648	0.941	45

****
* END PPMCR OUTPUT *
****

TIME USED BY PPMCR - 3 SECONDS

RECORDS PRODUCED BY PPMCR - 177

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12.00   EXECUTE FANAL
13.00   MINIMUM VARIANCE 1.0
14.00   VARIABLE NAMES TRANSFER
15.00   INPUT FROM BEMCR
16.00   STOP
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*                           *
* BEGIN    FANAL    OUTPUT  *
*                           *
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THIS PROGRAM WAS LAST REVISED ON APRIL 30, 1973

THE WRITE-UP WAS LAST REVISED ON 02/26/69

NUMBER OF VARIABLES = 15

NUMBER OF FACTORS TO BE EXTRACTED = 15

MINIMUM VARIANCE = 1.00000

ALL DIAGONAL ELEMENTS WERE ASSUMED TO BE 1.0

SUM OF DIAGONAL ELEMENTS (TRACE) = 15.00

PRINCIPAL COMPONENTS ANALYSIS

FACTOR NUMBER		VARIABLE	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED	PERCENT OF TRACE	CUMULATIVE PERCENT
1	TTSP TOT	1	0.79701	9.85690	0.23500	10	65.71	65.71
	TTSP CIA	2	0.15738		0.05013			
	TSPT TOT	3	0.90929		0.26325			
	TSPT TIM	4	-0.08101		-0.02609			
	SFTAA VE	5	0.90769		0.28274			
	SFTAA NO	6	0.94317		0.26056			
	SFTAA TO	7	0.94916		0.30232			
	CTBS RDG	8	0.90776		0.28914			
	CTBS REG	9	0.87915		0.28003			
	CTBS LAN	10	0.90438		0.28168			
	CTBS MAT	11	0.90346		0.28458			
	CTBS SCI	12	0.87564		0.27890			
	CTBS SOC	13	0.87407		0.28877			
	RPT CARD	14	0.74951		0.23857			
	OTIS IQ	15	0.88650		0.28236			

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PRINCIPAL COMPONENTS ANALYSIS

FACTOR NUMBER		VARIABLE	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED	PERCENT OF TRACE	CUMULATIVE PERCENT
2	TTSP TOT	1	0.09311	1.09956	0.08883	60	7.32	73.04
	TTSP CLA	2	0.08819		0.04701			
	TSPT TOT	3	0.01776		0.01602			
	TSPT TIM	4	0.35970		0.34275			
	SFTAA VE	5	-0.12005		-0.11492			
	SFTAA NO	6	0.14228		0.13574			
	SFTAA TO	7	-0.00540		-0.05523			
	CTBS RDG	8	-0.12962		-0.12367			
	CTBS RDG	9	-0.17458		-0.17038			
	CTBS LAN	10	-0.09296		-0.08869			
	CTBS MAT	11	-0.07906		-0.02811			
	CTBS SCI	12	-0.06408		-0.06114			
	CTBS SOC	13	-0.08524		-0.08138			
	RPT CARD	14	0.13699		0.12985			
	OTIS IQ	15	0.21828		0.20826			

PRINCIPAL COMPONENTS ANALYSIS

FACTOR NUMBER		VARIABLE	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED	PERCENT OF TRACE	CUMULATIVE PERCENT
3	TTSP TOT	1	-0.04943	1.07914	-0.04758	11	7.19	80.23
	TTSP CLA	2	0.38876		0.37423			
	TSPT TOT	3	-0.15372		-0.14797			
	TSPT TIM	4	-0.89649		-0.86299			
	SFTAA VE	5	0.06260		0.06026			
	SFTAA NO	6	-0.01595		-0.01536			
	SFTAA TO	7	0.03166		0.03048			
	CTBS RDG	8	0.06123		0.05894			
	CTBS RDG	9	0.01189		0.01145			
	CTBS LAN	10	0.05101		0.04910			
	CTBS MAT	11	-0.01249		-0.01202			
	CTBS SCI	12	-0.05527		-0.05320			
	CTBS SOC	13	-0.05889		-0.05669			
	RPT CARD	14	-0.23344		-0.22472			
	OTIS IQ	15	0.15940		0.15345			

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PRINCIPAL COMPONENTS ANALYSIS

FACTOR NUMBER		VARIABLE	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED	PERCENT OF TRACE	CUMULATIVE PERCENT
4	TTSP TOT	1	-0.64135	0.58834	-0.70577	38	3.92	84.15
	TTSP CLA	2	0.04734		0.06249			
	TSPT TOT	3	0.03442		0.00488			
	TSPT TIM	4	0.19168		0.24990			
	SFTAA VR	5	0.25074		0.32689			
	SFTAA NO	6	-0.10733		-0.13993			
	SFTAA TO	7	0.10543		0.13746			
	CTBS RDG	8	0.12669		0.16517			
	CTBS RDG	9	0.07671		0.10000			
	CTBS LAN	10	-0.00428		-0.00558			
	CTBS MAT	11	-0.08456		-0.11025			
	CTBS SCI	12	-0.01556		-0.02029			
	CTBS SOC	13	0.05650		0.07366			
	RPT CARD	14	-0.27993		-0.36496			
	OTIS IQ	15	0.24218		0.31574			

NOTE - THIS PROBLEM REQUIRED 901 WORDS OF ARRAY STORAGE.

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*                           *
* END      FANAL     OUTPUT *
*                           *
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TIME USED BY FANAL - 1 SECONDS

RECORDS PRODUCED BY FANAL - 107

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12.00   EXECUTE FANAL
13.00   MINIMUM VARIANCE 1.0
14.00   VARIABLE NAMES TRANSFER
15.00   INPUT FROM PPMCR
16.00   STOP
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*                           *
* BEGIN    FANAL    OUTPUT  *
*                           *
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THIS PROGRAM WAS LAST REVISED ON APRIL 30, 1973

THE WRITE-UP WAS LAST REVISED ON 02/26/69

NUMBER OF VARIABLES = 15

NUMBER OF FACTORS TO BE EXTRACTED = 15

MINIMUM VARIANCE = 1.00000

ALL DIAGONAL ELEMENTS WERE ASSUMED TO BE 1.0

SUM OF DIAGONAL ELEMENTS (TRACE) = 15.00

APPENDIX N

DISCUSSION OF ADDITIONAL FINDINGS

Discussion of Additional Findings

In conjunction with the science supervisor and adhering to strict rules of confidentiality, two hundred, fifteen fifth grade students of the Lewisburg Area School System were coded and scores of their performance on fifteen variables were recorded on a data matrix. Data were transferred to EDP cards and processed at the Computer Center of The Pennsylvania State University using the Pearson product-moment correlation and the Factor Analysis of the Statistical Package Program. Variables included: (1) the total score of the _Television Test of Science Processes_, (2) scores of those questions within the TTSP identified by Tannenbaum as classification questions, (3) the total score of _The Science Process Test_, (4) the time in minutes required by the students to take _The Science Process Test_, (5) the verbal score of the _Short Form Test of Academic Aptitude_ (SFTAA), (6) the non-verbal score of the SFTAA, (7) the weighted total score of the SFTAA, (8) the reading vocabulary score of the _Comprehensive Test of Basic Skills_ (CTBS), (9) the reading comprehension score of the CTBS, (10) the weighted language total score of the CTBS, (11) the math score of the CTBS, (12) the science score of the CTBS, (13) the social studies score of the CTBS, (14) the science grade on the mid-year report card given on a continuum of 0 through 4, and (15) the Otis-Lenon I.Q. score recorded for those of the validity population who attended school in grade four in the Lewisburg Area School District.

A summary of the Pearson product-moment correlation of the fifteen variables is shown in Table 11 in Chapter 4. The correlations of the TTSP total score with all the variables, excepting variables 2 and 4, were moderately to highly correlated and were significant at the one percent level. The low correlation between the TTSP and variable 2, the identified classification questions on the TTSP, could be explained by the small number of questions (four) identified as classification. The low correlation between the TTSP and variable 4, the time in minutes required to take The Science Process Test, was expected. Variable 4 does not correlate with any of the variables. A low negative correlation is the characteristic pattern for performance time with measures of achievement (Roberts, 1967).

A summary of the factor analysis shows that all variables except 2 and 4 have high factor loadings on Factor 1. In addition, Factors 2 and 4 are defined by one variable only and the variables that define Factors 2 and 4 are different. Therefore, it appears that all the variables assess one strong general factor. Table 12 shows a summary of the principle component analysis for Factor 1. The complete computer printout for the PPMCR and the Final Program is shown in Appendix M. Factor 1 accounts for 65.71 percent of the variance. This was similar to what was found in the work by Tannenbaum (1968) and Ludeman (1974).

Tannenbaum, in searching for the uniqueness of his subscores, subjected his data to a factor analysis of the matrix of intercorrelations of his subscores. He states:

TABLE 12

PRINCIPLE COMPONENTS FACTOR ANALYSIS FOR FACTOR ONE

VARIABLE	FACTOR LOADING	VARIABLE	FACTOR LOADING
1	.738	8	.908
2	.157	9	.879
3	.889	10	.884
4	-.083	11	.893
5	.888	12	.876
6	.843	13	.894
7	.949	14	.749
		15	.887

> The analysis was first performed with unity in the principle diagonal and the result was one general factor, about evenly weighted on all subscores, which accounted for about ten percent of the variance. No other factors accounted for as much as eight percent of the variance.
>
> By rotating the first two factors, it was possible to force them to appear to be a first-half-of-the-test factor and a second-half-of-the-test factor. But this was not very obvious and a much more defensible interpretation would be one general factor (perhaps "intelligence") and no other significant factors. (Tannenbaum, 1968, p. 114)

It would seem that the most reasonable conclusion to be drawn from the factor analysis is that there is one large general factor (probably "intelligence") which accounts for about half of the non-error variance and that there are probably no other major

> factors which involve more than one of the sub-scores. This leaves about fifty percent of the non-error variance to be accounted for by the individual subscores. (Tannenbaum, 1968, p. 117)

Tannenbaum urges caution in the use of subscores due to their low reliabilities.

The date of Ludeman (1974) did not permit rejection of the null form of his hypothesis that the Integrated Process which a given test item assesses will be indicated by the students' scores on the item having a significantly higher correlation with their scores on that Integrated Process subtest than on any other subtest on the Individual Competency Measures. In his discussion, Ludeman concluded:

> To elucidate the absence of significant differences among the TSPT item -- Individual Competency Measures subscale correlations, the intercorrelation among the Integrated Processes subscales of the Individual Competency Measures were calculated. A t test of significance of differences indicated no significant differences at the .01 level. Thus, it can be argued that they are all measuring similar abilities and so, it would be very hard to find a test item that would correlate significantly higher with one subtest than with another. (Ludeman, 1974, pp. 60-61)

Factor 1 accounts for 65.71 percent of the trace on the Principle Component Analysis. It could be inferred that approximately two-thirds of the variance of the measures of science processes can be accounted for by intelligence, reading ability, general achievement, etc. Possibly the characteristic being assessed in science process tests simply reflects general problem solving ability. Also, the unique skills and abilities identified as the processes of observing, comparing, measuring, etc. are not totally unique or mutually exclusive.

While there is much agreement on the need for the benefit from including within the teaching-learning process activities which utilize those skills and abilities attributed to scientists and the scientific method which collectively are called science processes, a conclusion can be drawn that there is no unified definition or enumeration of those separate and semantically identifiable processes. Also, the validity of a test instrument designed to measure a student's performance in his ability to use those processes must, in the absence of an empirically unique characteristic or cognitive function, rely heavily on face or content validity. A measure of the unique process ability or characteristic rests to a large degree on inferences derived empirically from data which suggests performance on characteristics which are similar and generalizable within the perimeters of an accepted definition.

In an effort to isolate the unique ability or characteristic, the data generated from the validity study was further examined. Of the fifteen variables summarized in Table 11, variables 2, 4, 7, 10, and 15 were eliminated from the data. Variables 2 (TTSP classification score), 4 (TSPT time), 7 (SFTAA total score), and 10 (CTBS language total score) were dependent scores; that is, these variables are the weighted sum of other variables, and eliminated from the data. Variable 15 (Otis-Lenon I.Q.) was eliminated because of the small number of data points in the sample.

Pearson product-moment intercorrelations were computed for all variables and then factor analyzed using the principal components program Fanal. Interations were continued until a criterion of one percent of the total variance was met. In addition, factors were rotated to simple structure using the Varimax program. Two factors were found.

A summary of the rotated matrix of factor loadings is summarized in Table 13.

TABLE 13

THE ROTATED MATRIX OF FACTOR LOADINGS OF TEN VARIABLES

VARIABLE	FACTOR 1	FACTOR 2
TTSP	.348	.763
TSPT	.658	.600
SFT-VERB	.872	.326
SFT-NON	.464	.748
VOCAB	.836	.433
COMP	.841	.405
MATH	.580	.684
SCIENCE	.736	.510
SOC-ST	.768	.501
RPT-CARD	.319	.793

The complete computer printout for the Varimax Rotation is shown in Appendix O. Given an arbitrary loading criteria of .3, all the variables load significantly on both factors. However, the data shows the variables grouping more heavily on Factor 1 are the SFTAA verbal score, the CTBS reading vocabulary score, and the CTBS reading comprehension score. Those variables grouping more heavily on Factor 2 are the TTSP and the science grade on the mid-year report card. The Television Test of Science Processes, while moderately to highly correlated with all the independent variables, is most highly correlated on the factor rotation with report card grades. If those characteristics identified, measured, and recorded on course grade report cards reflect student proficiency in the science processes to some degree, it then must be inferred that the high correlation of the TTSP to these report card grades is a strong statement of criterion-related validity of the instrument. A conclusion can be inferred from the data that the Television Test of Science Processes is a statistically reliable and valid instrument to assess achievement is the science processes for students in grades five and six.

APPENDIX O

COMPUTER PRINTOUT OF THE STATISTICAL PACKAGE PROGRAM OF THE VALIDITY SAMPLE ON TEN SELECTED VARIABLES

```
*****************************
*                           *
* BEGIN    STPAC    OUTPUT  *
*                           *
*****************************

THERE ARE     9192 WORDS OF CORE AVAILABLE FOR ARRAY STORAGE DURING THIS RUN.

THERE ARE     12288 BYTES OF CORE AVAILABLE FOR I/O BUFFERS

        1.00    EXECUTE PRMCR
        2.00    VARIABLES 10.
        3.00    FORMAT (3X,F3.0,3X,F3.0,3X,2F3.0,3X,2F3.0,3X,4F3.0)
        4.00    VARIABLE NAMES 1=TISP,2=TSPT,3=SPT-VERB,4=SPT-NON,5=VOCAB,6=COMP,7=MATH,
        5.00    VARIABLE NAMES 8=SCIENCE,9=SOC-ST,10=RPT-CARD
        6.00    MISSING DATA 0.0
        7.00    BEGIN DATA
                001021002017024102060081501497466165504442002
                002219902130311151151756337126165636837190093
                004319224022327107129109557541527476403571003
                005030004028021105112113601602695590500615004
                007922031126020120117121557602560552563719003
                009024002031023115111111055762955359066057100
                009025    015028120105117557520531476561580003
                012025013932010127121129601679641580710683004
                011921002025010111110116541567517517577559002
                012027902026027126130130577712531517710683004

                        TOTAL OF     176 DATA CARDS

        8.00    END DATA
```

```
******************************
*                            *
* BEGIN     DPPCR     OUTPUT *
*                            *
******************************
```

THIS PROGRAM WAS LAST REVISED ON MAY 9, 1972

THE WRITE-UP WAS LAST REVISED ON MAY 9, 1972

THE RAW DATA FOR THIS PROBLEM CONTAINS 10 VARIABLES

THE FORMAT OF THE DATA IS - (3X,F3.0,3X,F3.0,3X,2F3.0,3X,2F3.0,3X,4F3.0)

MISSING DATA IS DESIGNATED BY A VALUE OF 0.0

THE FIRST CASE WAS READ AND INTERPRETED AS FOLLOWS:

VARIABLE		VALUE	VARIABLE		VALUE	VARIABLE		VALUE	VARIABLE		VALUE
TTSP	1	23.0000	TSPT	2	17.0000	SPT-VERB	3	100.0000	SPT-NON	4	60.0000
VOCAB	5	541.0000	COMP	6	497.0000	MATH	7	365.0000	SCIENCE	8	504.0000
SOC-ST	9	442.0000	ENP-CARD	10	2.0000						

TOTAL NUMBER OF DATA CARDS PROCESSED: 176 NUMBER OF OBSERVATIONS: 176

VARIABLE	MEAN	STD. DEV.	NOBS	VARIABLE	MEAN	STD. DEV.	NOBS	VARIABLE	MEAN	STD. DEV.	NOBS
1 TTSP	19.1608	6.49757	176	5 VOCAB	490.7159	90.21258	176	9 SOC-ST	518.9205	98.16787	176
2 TSPT	20.2110	7.14751	176	6 COMP	516.9580	99.91103	176	10 RPT-CARD	2.5497	0.87558	171
3 SET-VERB	102.9175	15.29429	176	7 MATH	459.0692	91.82718	176				
4 SET-NON	100.1193	16.36590	176	8 SCIENCE	522.9659	80.82907	176				

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PAIR X		Y	R	MEAN X	MEAN Y	ST.DEV.X	ST.DEV.Y	N
TSPT	2-	1 TTSP	0.660	20.211	19.223	7.140	6.470	175
SET-VERB	3-	1 TTSP	0.561	102.939	19.165	15.286	6.498	176
SET-VERB	3-	2 TSPT	0.757	103.038	20.211	15.276	7.148	175
SET-NON	4-	1 TTSP	0.631	104.119	19.165	16.366	6.498	176
SET-NON	4-	2 TSPT	0.723	104.171	20.211	16.398	7.148	175
SET-NON	4-	3 SET-VERB	0.663	104.119	102.930	16.366	15.286	176
VOCAB	5-	1 TTSP	0.639	498.716	19.165	84.213	6.498	176
VOCAB	5-	2 TSPT	0.783	499.171	20.211	84.236	7.148	175
VOCAB	5-	3 SET-VERB	0.862	498.716	102.938	84.213	15.286	176
VOCAB	5-	4 SET-NON	0.682	499.716	104.119	84.213	16.366	176
COMP	6-	1 TTSP	0.616	516.959	19.165	99.911	6.498	176
COMP	6-	2 TSPT	0.765	517.251	20.211	100.061	7.148	175
COMP	6-	3 SET-VERB	0.813	516.958	102.938	99.911	15.286	176
COMP	6-	4 SET-NON	0.662	516.658	104.119	99.911	16.366	176
COMP	6-	5 VOCAB	0.861	516.958	498.716	99.911	84.213	176
MATH	7-	1 TTSP	0.650	459.068	19.165	81.827	6.498	176
MATH	7-	2 TSPT	0.768	459.369	20.211	81.970	7.148	175
MATH	7-	3 SET-VERB	0.702	459.068	102.938	81.827	15.286	176
MATH	7-	4 SET-NON	0.800	459.068	104.119	81.827	16.366	176
MATH	7-	5 VOCAB	0.756	459.068	499.716	81.827	84.213	176
MATH	7-	6 COMP	0.757	459.068	516.958	81.827	99.911	176
SCIENCE	8-	1 TTSP	0.663	522.966	19.165	88.829	6.498	176
SCIENCE	8-	2 TSPT	0.769	522.460	20.211	88.765	7.148	175
SCIENCE	8-	3 SET-VERB	0.762	522.966	102.938	88.829	15.286	176
SCIENCE	8-	4 SET-NON	0.712	522.966	104.119	88.829	16.366	176
SCIENCE	8-	5 VOCAB	0.900	522.966	499.716	88.829	84.213	176
SCIENCE	8-	6 COMP	0.808	522.966	516.858	88.829	99.911	176
SCIENCE	8-	7 MATH	0.766	522.966	459.068	88.829	81.827	176
SOC-ST	9-	1 TTSP	0.645	518.929	19.165	98.168	6.498	176
SOC-ST	9-	2 TSPT	0.709	519.314	20.211	98.310	7.148	175
SOC-ST	9-	3 SET-VERB	0.793	518.929	102.938	98.168	15.286	176
SOC-ST	9-	4 SET-NON	0.735	518.929	104.119	98.168	16.366	176
SOC-ST	9-	5 VOCAB	0.832	518.929	499.716	98.168	84.213	176
SOC-ST	9-	6 COMP	0.838	518.929	516.958	98.168	99.911	176
SOC-ST	9-	7 MATH	0.781	518.929	459.068	98.168	81.827	176
SOC-ST	9-	8 SCIENCE	0.776	518.929	522.966	98.168	88.829	176
RPT-CARD	10-	1 TTSP	0.575	2.550	19.201	0.970	6.503	171
RPT-CARD	10-	2 TSPT	0.679	2.553	20.494	0.877	7.032	170
RPT-CARD	10-	3 SET-VERB	0.576	2.550	103.292	0.876	15.273	171
RPT-CARD	10-	4 SET-NON	0.651	2.550	104.427	0.876	16.497	171
RPT-CARD	10-	5 VOCAB	0.651	2.550	503.062	0.876	84.356	171
RPT-CARD	10-	6 COMP	0.671	2.550	519.263	0.876	98.370	171
RPT-CARD	10-	7 MATH	0.661	2.550	461.602	0.876	81.491	171
RPT-CARD	10-	8 SCIENCE	0.580	2.550	526.117	0.876	87.516	171
RPT-CARD	10-	9 SOC-ST	0.631	2.550	521.910	0.876	96.831	171

```
*****************************
*                           *
* END       PPMCR    OUTPUT *
*                           *
*****************************

TIME USED BY PPMCR      -     1 SECONDS

RECORDS PRODUCED BY PPMCR     -     102
```

```
 9.00   EXECUTE PANAL
10.00   VARIABLES 10
11.00   VARIABLE NAMES TRANSFER
12.00   MINIMUM VARIANCE 1.0
13.00   INPUT FROM PPMCR
```

```
******************************
*                            *
* BEGIN    FANAL    OUTPUT   *
*                            *
******************************
```

THIS PROGRAM WAS LAST REVISED ON APRIL 30, 1973

THE WRITE-UP WAS LAST REVISED ON 02/26/69

NUMBER OF VARIABLES = 10

NUMBER OF FACTORS TO BE EXTRACTED = 10

MINIMUM VARIANCE = 1.00000

ALL DIAGONAL ELEMENTS WERE ASSUMED TO BE 1.0

SUM OF DIAGONAL ELEMENTS (TRACE) = 10.00

PRINCIPAL COMPONENTS ANALYSIS

FACTOR NUMBER		VARIABLE	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED	PERCENT OF TRACE	CUMULATIVE PERCENT
1	TTCP	1	[illegible]	7.07389	0.27923	7	74.74	74.74
	TSPT	2	[illegible]		0.32588			
	SPT-VERB	3	[illegible]		0.31881			
	SPT-NON	4	[illegible]		0.30776			
	VOCAB	5	[illegible]		0.33453			
	COMP	6	[illegible]		0.32935			
	MATH	7	[illegible]		0.32421			
	SCIENCE	8	[illegible]		0.32547			
	SOC-ST	9	[illegible]		0.33237			
	RPT-CARD	10	[illegible]		0.27852			

FACTOR NUMBER		VARIABLE	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED	PERCENT OF TRACE	CUMULATIVE PERCENT
2	TISP	1	0.30664	0.60049	0.44733	23	6.00	80.74
	TSPT	2	0.02911		0.02595			
	SPT-VERB	3	-0.32722		-0.42227			
	SPT-NOM	4	0.25879		0.33596			
	VOCAB	5	-0.22318		-0.20800			
	COMP	6	-0.28751		-0.31940			
	MATH	7	0.13455		0.17363			
	SCIENCE	8	-0.09969		-0.12735			
	SOC-ST	9	-0.12690		-0.16376			
	RPT-CARD	10	0.38842		0.50124			

NOTE - THIS PROBLEM REQUIRED 401 WORDS OF ARRAY STORAGE.

```
******************************
*                            *
*  END     FANAL     OUTPUT  *
*                            *
******************************
```

TIME USED BY FANAL - 1 SECONDS

RECORDS PRODUCED BY FANAL - 59

```
14.00   EXECUTE VARMX
15.00   VARIABLES 10
16.00   VARIABLE NAMES TRANSFER
17.00   ROTATE 3 7
18.00   INPUT FROM PANAL
19.00   STOP
```

```
****************************
*                          *
* BEGIN    VARMX    OUTPUT *
*                          *
****************************
```

THIS PROGRAM WAS LAST REVISED ON 12/15/72

THE WRITE-UP WAS LAST REVISED ON 03/04/69

VARIMAX ROTATION

THE INPUT MATRIX FROM FACTOR ANALYSIS CONTAINS 10 VARIABLES AND 2 FACTORS.

*** ERROR - YOUR REQUEST TO ROTATE 1 FACTORS IS NOT VALID - REQUEST IGNORED.

VARIMAX ROTATION

ROTATION OF FIRST 2 FACTORS

COMMUNALITIES

TTSP	1	0.70291	SFT-NON	4	0.77086	MATH	7	0.80369	PPT-CARD	10	0.73066
TSPT	2	0.79412	VOCAB	5	0.80623	SCIENCE	8	0.80145			
SFT-VERB	3	0.86672	COMP	6	0.87196	SOC-ST	9	0.84176			

THE ROTATED MATRIX OF FACTOR LOADINGS

		FACTOR 1	FACTOR 2
TTSP	1	0.34783	0.76290
TSPT	2	0.65949	0.60043
SFT-VERB	3	0.87218	0.32596
SFT-NON	4	0.46933	0.74794
VOCAB	5	0.83614	0.43255
COMP	6	0.84144	0.40489
MATH	7	0.57996	0.69371
SCIENCE	8	0.71569	0.51013
SOC-ST	9	0.76984	0.59126
RPT-CARD	10	0.31992	0.79336

SUM OF SQUARED ROTATED FACTOR LOADINGS

	SUM FOR EACH COLUMN	PERCENT OF TRACT
FACTOR 1	4.5076	45.08
FACTOR 2	3.5669	35.67

```
****************************
*                          *
* END      VARMX    OUTPUT *
*                          *
****************************
```

TIME USED BY VARMX - 1 SECONDS

RECORDS PRODUCED BY VARMX - 62

```
*****************************
*                           *
* END      STRAC     OUTPUT *
*                           *
*****************************
```

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236

```
ACCOUNT: [illegible]          MAXIMUM TIME (SEC): [illegible]  NET CPU (SEC): 2
DATE: 05/07/76 [illegible]    ACTUAL TIME, INCLUDING [illegible] SYSTEM TIME:  11 @ $.10/SEC = $ 1.10
USER: TORRENCE DAVID [illegible]  LINES PRINTED: 265  CARDS PUNCHED:  0 @ $.17/100 = $ 0.00
DESTINATION: [illegible]      MAXIMUM RECORDS: [illegible]  TOTAL RECORDS:  265 @ $.06/100 = $ 0.18
[illegible]-21,[illegible]    CARDS READ: [illegible]   *****TOTAL COST = $ 1.28  JOB NAME [illegible] 18804
```

The Television Test of Science Processes

by

David R. Torrence

An Abstract of a Thesis

in

Academic Curriculum and Instruction

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Education

August 1976

The Pennsylvania State University
The Graduate School
Department of Academic Curriculum and Instruction

The Television Test of Science Processes

In 1972, The Pennsylvania State University and the Pennsylvania Department of Education (PDE) devised a system for using instructional television as a major resource in the implementation of Science for the Seventies (SFTS), a statewide thrust to assist elementary teachers in a transition into some of the newer methods of teaching science. One of the objectives of this ITV resource is to measure student competency in the use of science processes via a televised test.

A review of the literature found no test with the combined requirements of being content valid for use by intermediate level students and for administration via television. Of the available tests, the Test of Science Processes (TSP) was found adaptable for revision because it possessed content validity. Most applicable to the SFTS demands was its visual presentation mode which had implication for the television format.

There were two aspects to the problem investigated in this study. First, could the TSP be modified for use by intermediate level students? Second, could the TSP be adapted as a reliable and valid test for use through the medium of television?

An item pool was generated from the ninety-six items of the TSP which were identified as representative of the process skills and their applicability to intermediate level students.

A prototype Television Test of Science Processes (TTSP) was formulated. The print component consisted of a television test booklet and teacher's manual. The verbal message was modified and subjected to two readability measures. Vocabulary and syntax were computed to be at the third grade level.

The non-print component was reviewed and organized in a television script into the audio and visual modes. The total information utilized was the necessary introductory comments and audio directions for test taking and the narration of the test questions. Using the production studio of WPSX, Form A of the TTSP was produced on two-inch tape of broadcast quality.

A study to ascertain the appropriate timing for each of the visuals was conducted. A cutting time was generated for each question and the video tape was edited to become Form B of the test instrument. A pilot exposure to derive item analysis data was conducted and, based on their biserial coefficients and item difficulties, forty items were identified for inclusion into Form C. Revision of the entire print and non-print component was affected. An edit of the video tape was conducted to include appropriate credits and to conform to the time limits of two thirty-minute programs required for public broadcasting.

To determine validity, two hundred, fifteen students of a large central Pennsylvania school system were given the TTSP, the Science Process Test (TSPT) and the Science Test of the Comprehensive Tests of Basic Skills (CTBS). These and other data were factor analyzed. The TTSP, Form C was found moderately to highly correlated with TSPT and the Science Test of the CTBS.

Test results from three thousand, four hundred eighty fifth grade students from nineteen school systems were processed and used for developing initial norms.

The data suggests content validity, appropriate readability, internal reliability coefficients, approximating comparable reliability coefficients of tests of science processes, criterion related validity through moderate to high correlation with similar instruments, and a norming distribution with a moderate unimodal skew approximating a normal curve. It can be inferred that the successful formulation of the TTSP implies that the TSP has been modified for use for intermediate level students and has been adapted for use through the medium of television.

VITA

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Date of Birth: 5/12/37

Marital Status: married 12 years, no children

Education:
- B.S. Social Science and Education, 1964
  Towson State College, Maryland
- M.S. Curriculum and Instruction, 1969
  The Pennsylvania State University
- D.Ed. Curriculum and Instruction (Instructional Development) 1976
  The Pennsylvania State University

Professional Interests: Instructional technology, Instructional and Staff development

Special Interests: graphic arts, mediated learning experiences

Teaching Experience:
- 3 years - Social Studies, Parkville Junior High School, Baltimore, MD
- 1 year -- Geography, Parkville Senior High School, Baltimore, MD
- 1 year -- Supervision of Student Teachers, The Pennsylvania State University (Supervision Internship Program)
- 3 years - Weather and Climate, Physiography, Earth Science, Regional, World, and Wisconsin Geography, University of Wisconsin Center-Medford, Wisconsin
- 3 years - Instructional Development and Media (Teaching Assistantship) The Pennsylvania State University

Teaching Certificates:
- Maryland -- Secondary Social Studies, Geography
- Pennsylvania -- Media Specialist

Awards, Fellowships, Grants:
- N.D.E.A. Fellowship in Geography -- The Pennsylvania State University, 1967
- Supervision Internship -- The Pennsylvania State University, 1968
- N.S.F. Grant-Moisture and Energy Balance Climatology -- University of Delaware, Summer, 1971

References include:
Dr. Paul Welliver, The Pennsylvania State University
Dr. Russell Oliver, University of Wisconsin Center-Medford
Mrs. Sue Zoller, Baltimore County Public Schools

Credentials are available from: Teacher Placement Service
The Pennsylvania State University
408 Boucke Building
University Park, PA 168C2